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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

MARCH 9.

Institution of Engineering Inspection:—Fifth meeting of the Session, at Royal Society of Arts, London. Paper will be read by L. Nicholson, A.M.I.E.E., on "Limit System in Relation to Production and Inspection, and Some Inspection Problems."

Junior Institute of Engineers:—Informal meeting. Lecturette, "Air Compressors," by E. S. Huntingford.

MARCH 13.

Institute of Marine Engineers:—Ordinary meeting in London. "Recent Developments in Propelling Equipment Practice of Reciprocating Engined Steamers," Paper by G. R. Hutchinson.

MARCH 16.

Society of Chemical Industry (Birmingham and Midland Section):—Ordinary meeting. "Coloured Glasses," Paper by Dr. W. M. Hampton, B.Sc.

Institute of British Foundrymen.

MARCH 10.

Newcastle and District Branch:—Joint meeting with the Junior Section. Visit to South Shields Electric Power Station and Ironfoundry of Messrs. Smith & Company, Limited.

London Junior Section:—Works visit to Messrs. Gillett & Johnston (The Croydon Bell Foundry, Limited).

MARCH 14.

Sheffield and District Branch:—Joint meeting with kindred scientific societies at Sheffield.

Industry and Education.

A recent report dealing with the relationship between industry and technical education puts forward some questions that are deserving of careful consideration. It is in the first place emphatically shown that no widespread doubt exists any longer as to the need for and the value of technical education; secondly, that its scope, nature, and amount are all open at present to considerable criticism; and, thirdly, that there is urgent need of much more active co-operation between the industrialists and the educationists in a matter that concerns them jointly.

In a few quarters, however, doubts are still expressed as to the potentialities of technical education as provided in technical schools and colleges for would-be artisans. A lad can clearly learn his job so much better in the shop or the foundry than under the necessarily artificial conditions of a technical class; indeed, it is only there that he can really learn it at all. But, on the other hand, the amount of definite training and instruction that can be given under normal working conditions, or even in a special training shop alongside them, is necessarily limited, and it is for this reason that the technical school has to be called in to remedy the deficiencies, so to speak, of works that cannot or will not undertake proper apprentice training.

Even under the best conditions, however, while a lad may learn supremely well the technique of the one job or group of jobs with which he is regularly and constantly concerned, unless the works is exceptionally large and exceptionally well organised, his training will stop there. Any wider knowledge of his trade, or of the reasons and theories that underlie his practice and so forth, are outside the scope of the training received in the average workshop. A boy in a light-castings foundry who desired experience in heavy jobs would find himself seriously limited. It is suggested that the remedy is attendance at technical schools, but it is open to grave doubt whether the technical school can fill the gap. Probably no school could do so.

The report insists that co-operation between the two parties concerned is essential. It can be effected in various ways. One is by the selection of teachers who are not only able to teach but who also know something of the industry from which their students come, and to which they will take their new knowledge. Such teachers, unfortunately, are not too easy to find. It may also be done by the presence of industrial men—either employers or employed—on local education committees, specifically in their capacity of employers or employed, and not merely as private citizens.

Whatever the method, the end must be the same, to ensure that the industry and the education related to it are in line and in sympathy. Only then will it become obvious and easy to encourage attendance at technical schools, and only then will the schools receive the support for which they clamour.

We shall return to this matter with special reference to the problem of training the foundryman, which is of such importance that the Institute of British Foundrymen and the Cast Iron Research Association have recently set up a joint committee to deal with it.

The Reason Why.

We awaited with some interest the delivery of Dr. Rosenhain's presidential address to the Institute of Metals, and we were delighted when we found it was to be addressed to practical men. No doubt some of the operatives will still be unable to follow the reasoning, but even they will appreciate that with just a little extra training in physics and chemistry they would be in a position to pick the plums from the academic pie made primarily for them by the research worker and served up as equilibrium diagrams. The new president has always been outstanding in his insistence on purity of raw materials as a fundamental principle in exploring the properties and potentialities of metals and alloys. He has been greeted with the remark that in practice one has to use commercially competitive materials, forgetting that a profound knowledge of the character of these materials of commerce can only be obtained by working on still purer stuff. Dr. Rosenhain's arguments are justified up to the hilt by following the history of "common talk" in ironfoundry circles. It can scarcely be denied that the following factors have dominated foundry thought at some period or other. Years ago every ill was ascribed to the sulphur content. Later, Professor Turner's classic research on silicon in cast iron made many think that the complete story was then available, and no further work need be done, and, may be, progress was temporarily arrested. Later, Cook and Hailstone's phosphide network claimed attention, which was followed by a swing of the pendulum back to the adequate balancing of the sulphur and the manganese. More recently an insistence on an all-pearlitic structure was the topic of conversation, whilst if we can read the minds of the thinking foundryman to-day we should say that he stresses most strongly the nature and amount of the graphite content. Actually, every one of these factors is important, and their consideration by two decades of foundrymen has, on a conservative estimate, put 50 per cent. on to the tensile strength of good material. But we still need many more fundamental data to minimise the worries of the founder. Like the medical profession, who surround themselves with ever-growing hospitals and a huge related industry, but whose main object still remains the rendering obsolete of such matters, so, too, the true objective of metallurgical research is to simplify and render foolproof the production of articles of commerce, using quite everyday materials.

Moulding Sands.

There was an interesting discussion on Moulding Sands at the meeting of the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen, held at the Engineers' Club, Waterloo Street, Birmingham, on Saturday night, February 25. Mr. F. G. Starr (Branch-President) was in the chair.

The subject was introduced by Mr. A. Logan, of Newcastle-on-Tyne, whose paper has already been published. Mr. Logan commented upon the fact that although there had been a fair amount of research work carried out on sands, there was little attempt in the average foundry to correlate practice with that research work. This was the more surprising in that sand was the one material in the foundry which was used more than any other, and was indeed the very basis of moulding. In this connection he paid a tribute to the moulder, because a good moulder, he said, possessed almost an instinct for determining the suitability or otherwise of sand for his particular purpose. Sometimes, however, he might be misled, going astray and turning out a few wasters, or imagining that the particular class of work on which he was engaged could only be done by the use of sand from a distance, costing a great deal more than sand nearer home.

Opening the discussion, Mr. J. G. Pearce said this country was unique in its resources so far as moulding sands were concerned. British moulding sand was almost fool-proof in the foundry. That state of affairs, however, would not be permanent. While at present no founder in this country had very far to go for reasonably good moulding sand, the deposits were becoming worked out. Other things were happening which were loading the dice against the founder. For example, some quarries, finding their deposits going, were blending sands for the benefit of the founder. He contended that if any blending was to be done, it ought to be done at the foundry. With the more exacting requirements of engineers, and the introduction of sand blasting and the use of oil sand cores, a technique of sand testing was demanded. It was foolish to instal elaborate sand testing plant, and equipment for treating sand, unless they knew something about the sand. Mr. Logan had referred to the skill possessed by the experienced moulder in mixing sands, but with modern tendencies towards mass production and specialisation it was gradually being found necessary to take the treatment of sand out of the hands of the individual moulder.

Mr. E. J. Lewis said that some of them who had to make castings to sell, and not to an individual firm, were so cut down as regarded price that they had to employ a large proportion of unskilled labour. Whilst a skilled moulder will be able to get his sand to 1¼ per cent. variation, he was afraid that very few moulders could even do that. The difficulty that he personally experienced was more concerned with the amount of water in the sand than anything else. While they were not so much affected in the ironfoundry, in the aluminium shop it was certainly vital. The surface of the casting would not be affected, but they were troubled with a large degree of cracking in the casting. It seemed to him that the only way out for the founder was to dry his sand and start from a rock-bottom basis.

Mr. W. J. Flavell thought it might be news to the lecturer that only a little more than a mile from the meeting place there was one of the finest beds of red sand in the United Kingdom, and there was much of it still left.

Mr. D. McQueen said he had never come across another sand that was equal to Erith sand for green-sand and light moulding. Moreover, it was a very fine sand and gave a very good skin. Mr. Lewis had suggested the drying of the sand and redamping it. He (Mr. McQueen) was afraid that if they went to any green-sand moulder with that suggestion he would be very much opposed to it.

Mr. J. G. A. Skerl said machine moulding was becoming more general, owing to its cheapness and to the fact that unskilled labour sufficed. He had come across many troubles in machine moulding, simply because the semi-skilled moulder used to machine moulding could not use a moulding sand in the way it should be used. He had to be provided with a sand which was much more fool-proof than one would expect in the case of a skilled moulder. As a consequence, in those foundries which made a speciality of machine moulding they would find that there was a tendency to think more about sand problems than in ordinary foundries making large sections. The dampness of the sand and milling were all-important. The moisture content, especially in green sand work, and to some extent in dry sand work, could not be over-emphasised. As to milling, this should be done in a proper way—not too heavily nor too lightly. On the point whether it was advisable to dry sands and then add water, Mr. Skerl said that for new sands it might be advisable, but no founder used entirely new sand for green sand work. They therefore came to the question of whether floor sand should be dried. He contended that it should not be dried unless there was accommodation for a large amount of sand, because sand must be tempered. If they milled new sand and tested it straight away they would find that it had increased strength. If, however, they milled it and allowed it to stand for many hours they would find the strength increased still further. Time should be allowed for the water in the sand to distribute itself over the whole of the component materials. If they dried the sand they were destroying, to some extent, that temper.

Mr. Logan, in reply to some of the points raised in the discussion, agreed that the standard of quality demanded by engineers was becoming more critical from every point of view. As to the question of drying sand and starting from a dry sand basis, he thought that would be a very unsatisfactory and uneconomic thing to do. It would be better to determine the moisture content, afterwards adding water to bring it up to the correct degree of moistness.

On the proposition of Mr. Flavell, seconded by Mr. McQueen, Mr. Logan was heartily thanked for his address.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

The Perfect Casting.

To the Editor of the Foundry Trade Journal.

Sir,—I should much appreciate any information concerning some small model engine castings shown at the B.I. Fair, Birmingham. They were as smooth as glass and perfectly sharp in outline. The attendant told me that they were not sand-blasted, barrelled, filed or pickled, but were simply brushed and painted. Can any reader give any idea how this skin is produced? Any information would be greatly appreciated by.—Yours, etc.,

Model Engineer.

"Rosedale," Oxford.
March 4, 1928.

Record Breaking and Engine Parts.

To the Editor of The Foundry Trade Journal.

Sir,—We notice in your current issue a paragraph under the above heading, and in this connection think you may be interested to know that we had the honour of supplying the castings for the gearbox and differential casing of Captain Campbell's "Blue Bird."

These are supplied in a special heat-treated aluminium alloy, and the fact that the power transmitted amounts to nearly 900 h.p. affords a striking illustration of the strength and reliability which can be obtained in light alloy castings produced by specialists under modern conditions.—Yours, etc.,

For William Mills, Limited,
J. F. Paige, Deputy Manager.

Grove Street, Birmingham.
March 5, 1928.

At the annual meeting of the Institution of Chemical Engineers, to be held on Thursday and Friday, March 8 and 9, at the New Princes' Restaurant, London, a paper on "The Combustion of Powdered Coal; the Influence of the Degree of Fineness of the Particles," will be read by Dr. Burrows Moore, of University College, London.

Random Shots.

In view of my remarks about the historical connections of Staffordshire with the early iron and steel industry, I was particularly interested in Mr. Every's recent lecture on Sussex ironworks. While charcoal was the regular fuel for metal-working, the South, of course, had a great advantage, but with the development of mineral fuel the Midlands came into its own. In the year 1737, for instance, we are credibly informed that 9,000 tons of bar iron were annually produced within ten miles of Birmingham—no small figure for those days—while in 1788 the pig-iron produced in the Midlands was more than three times as great in quantity as that produced by any other single district in England and Wales.

* * *

It was a good deal earlier—1621, to be exact—when a patent was granted to Lord Dudley on behalf of his son, "Dud," for smelting with mineral fuel, but competent authorities seem more than a little doubtful as to how far his process was successful. The chief ground for doubt appears to be that no mention is made of coking the coal, and it is not easy to understand how raw coal could have been used with the primitive methods then customary. . . . But the early connection of the industry with the Midlands remains indisputable.

* * *

Among the famous names we find, for instance, that of the first Abraham Darby, born in 1676 at Sedgeley, near Dudley, of yeoman stock, which appears to have combined nail-making and agriculture. It was during the historic connection of the Darby family with the Coalbrookdale works that the first successful smelting of iron with mineral fuel was accomplished. . . . Roebuck and Garbett, the founders of the Carron works, were Birmingham men—Roebuck by adoption, since he was a Scots physician in practice there, while Garbett was a local business man. . . . Another was Matthew Boulton, who brought James Watt to Birmingham, and whose Soho works became famous. . . .

* * *

Schoolboy howlers are always popular, but too many of them have a manufactured air, and, like all manufactured jokes, are not really funny. I came across a few recently that seemed genuine enough, and were distinctly more subtle than most. One gem was that "Drake was the first man who sighted the Invisible Armada," while the best of the bunch was the statement that "During the reign of Elizabeth, Parliament frequently interfered and urged the sovereign to marry, a thing it would not have dreamt of doing in the reign of Henry VIII."

* * *

And even as I write, my eye falls upon a long list of carefully selected, and, I believe, prize-winning efforts—some of them indeed old and tried friends, but others of a delightful novelty. I have a lurking fondness myself for the old description of a Soviet as something a waiter carries on his arm, as well as for the assertion that Shakespeare "lived at Windsor with his Merry Wives."

* * *

But I had not previously heard that "London Matriculation is what you must do to get a job"—a startling reflection this upon our educational system—nor yet that Alfred the Great started a Chronicle which still exists as a morning newspaper. One wonders whether our worthy contemporary would feel the more flattered at the imputed antiquity or pained at the implied conservatism. . . . The definition of a passive verb as "when the subject is the sufferer, as, 'I am loved,'" will awake a responsive chord in many hearts, while the experts will, no doubt, set their wits to work when they hear that "James the Second gave birth to a son. . . ."

* * *

And lastly, the effort that seems to me beyond all question to be the authentic schoolboy speaking—"the mechanical advantage of having a long pump handle is that you can have someone to help you pump!"

Marksman.

Methods of Testing Calcium Carbide.

At a meeting of the British Acetylene and Welding Association, held at the Old Colony Club, Leadenhall Street, London, on Thursday, February 23, Mr. Arthur Stephenson (of Messrs. Allen, Liversidge, Limited) read a Paper on "Methods of Testing Calcium Carbide," this being a sequel to a previous Paper on the subject which he read before the Association a year ago. Mr. Alexander Jackson presided.

In his previous Paper Mr. Stephenson discussed various types of calcium carbide testing apparatus without stating any preference or criticising their construction. In this second Paper, however, he subjected them to a more critical analysis, with a view to picking out their good and bad qualities, and by a judicious combination of the more desirable features to try and arrive at the basis of some standard form of apparatus and method of testing which would combine convenience and facility in handling with that degree of accuracy which the Association had always considered to be of primary importance in the just and equitable application of its regulations as a basis for commercial contract.

Striking Importance of Quality Standard.

There were at present in operation in Europe, he said, two standards for quality—the 300 and the 280 litre standards. The higher standard of 300 litres per kilogram at S.T.P., (standard temperature and pressure) coincided with our British standard of 4.8 cub. ft. per lb. at S.T.P.: the lower standard of 280 litres per kilogram at S.T.P., which was the so-called International Standard, was equivalent to 4.49 cub. ft. per lb. at S.T.P. If all the calcium carbide imported into this country were of the International or lower standard, instead of to our own standard, the British consumers would lose something like 18,000,000 cub. ft. of acetylene per year, or would be compelled to buy something like £26,000 to £27,000 worth of calcium carbide extra to meet the normal demands. This discrepancy in total gas yield was equal to the normal demands of no less than 3,000 welding operators working on light sheet metal, such as aircraft, for a normal working year of 2,500 hours per operator; in other words, a loss equal to 7½ million operating hours per year. Such a loss was too colossal to contemplate, but the Board of Trade returns of imports of calcium carbide showed that there had been a marked increase recently, so that the figures he had given did not represent the worst conditions.

It must be obvious, therefore, that as Great Britain was a totally importing country, purchasing the whole of its requirements abroad, no relaxation either in the standards or the means for maintaining them could be permitted without serious detriment to the acetylene consumers of the country as a whole.

The differences in gas yield, however, were not altogether confined to the specified standards, because the methods and the means for testing which were set out under the various regulations could in themselves give rise to inaccuracies which were capable of further reducing the true gas yield appreciably. At the International Congress in Brussels in June of last year two communications were made—by Prof. Dr. Franekel, of Vienna, and Mr. Boutta, of Paris, respectively—on the subject of errors arising in the testing of calcium carbide due to the influence of water vapour in the presence of the gas at varying temperatures.

Standardised Methods or Normal Competence.

The regulations of the British Acetylene and Welding Association had not hitherto prescribed any definite method of testing or any special form of apparatus, but had always laid more stress on the selection of a competent analyst whose results could be obtained in a way most convenient to himself, or the facilities at his disposal. In this respect the Association had been fortunate in having the benefit of the services of Mr. Butterfield, in view of his exceptional experience and the special facilities which he had for accurate measurement of gases.

Careless Buying.

It must not be taken for granted that, because the regulations of the Association specified the higher gas yield standard, they precluded the importation or sale in this country of calcium carbide of a lower standard. It was a fact that calcium carbide manufactured to either standard was imported from the Continent and sold in this country without discrimination or classification as to quality; neither was there any external branding on its packages which would lead the user to know which standard or quality he had purchased. The consumer, however, was not altogether free from blame, because frequently he did not trouble to inquire: indeed, it was doubtful in many cases he was aware of any regulation or standards. The only remedy for this was to revise the regulations so as to provide for classification under more than one standard of quality, and to give due publicity to the revision; then the matter must be left with the consumer to take advantage of the benefits which the regulations afforded him.

Mr. Stephenson emphasised, however, that the revision of the regulations should not aim at preventing the importation or use of carbide of the lower standard, because there were cases where it was an advantage, provided the price was commensurate with the quality.

Gravimetric Method Preferred.

There were two distinctly different principles upon which the quantity of acetylene available in commercial grades of calcium carbide could be ascertained, *i.e.*, the gravimetric and the volumetric principles. The usual procedure for ascertaining the weight of anything was perhaps better understood in general than the procedure necessary for ascertaining the volume. This was particularly the case in regard to gases, because with volume measurements we were involved in measurements of temperature and pressure under which the volume was to be ascertained. Therefore, the weight method seemed to offer something which was definite and tangible, whereas the volume which any given weight of gas could occupy could be varied infinitely, according to temperature and pressure. Nevertheless, there was a definite relationship between these systems of measurement which enabled us to transpose conveniently from one to the other if the essential factors were known.

With regard to the gravimetric method of determining the quantity of acetylene yielded by calcium carbide, he said that gases under ordinary conditions had buoyancy, the extent of which varied with temperature and pressure. Therefore, in weighing a gas, special precautions must be taken to correct for this buoyancy effect, otherwise the results were inaccurate. In the gravimetric method we did not actually collect and weigh the gas, but we arrived at its weight by determining the loss in weight of the testing apparatus and contents which was brought about by decomposing the sample, so that, paradoxical though it might seem, we arrived at the weight of the gas without weighing it; therefore, the buoyancy effect did not come into consideration.

Conversion Data.

After examining the various features of the original and improved Bamberger apparatus for testing gravimetrically, Mr. Stephenson said the principal objection to the gravimetric method of testing was not lodged against its accuracy, but the time needed—from four to six hours—normally to carry out a test; hence the manufacturer of calcium carbide did not consider this a suitable method for routine testing. What was sometimes considered a further disadvantage was that this method gave results in terms of weight, and that the general public had always been taught to think of gas in terms of volume. The conversion was really a simple matter, but it was first necessary to settle the correct weight of unit volume of acetylene at the standard temperature and pressure. For ordinary commercial practice the value of 1.1 grms. per litre, or the English equivalent of 1.1 oz. per cub. ft., was sufficiently accurate, because it gave results which were within an error of 1 per cent.; but for more accurate determinations, such as the testing of calcium carbide, the value of 1.1079 should be substituted for 1.1. This more accurate value was arrived at by taking a fair average of the values obtained at various temperatures and pressures, and from twenty different authoritative sources, and the final results converted to the standard temperature and pressure of 15 deg. C. and 760 mm. mercury, which was practically equivalent to our English standard of 60 deg. Fah. and 30 in. of mercury.

This apparent disadvantage in the gravimetric method was in fact an advantage, because the results obtained were for dry gas; therefore, there was no correction to make for the presence of water vapour.

Volumetric Testing.

Dealing with the apparatus which operate on the volumetric principle, he pointed out that there were two distinct systems of working—the open and closed systems. In addition there were three different ways of arriving at the volume of gas produced from the sample. The three different systems of arriving at the volume of gas obtained were:—(1) Those in which the gas was collected and measured in a calibrated displacement type of gasholder; (2) those in which the gas was collected in a displacement type of gasholder, but not calibrated, the gas being taken from it to be measured by a supplementary metering device; and (3) those in which the gas was not collected at all, but was passed through and measured by the metering device as produced.

After examining the various types of volumetric apparatus, Mr. Stephenson said it would be agreed that the open system of testing was entirely inaccurate unless means were provided for measuring the exact amount of water which entered the system during the test; and that the accurate measurement of the volume, temperature and pressure of the gas as it was collected in the gasholder was practically impossible. With one exception, every gasholder apparatus he had dealt with endeavoured to do this, the exception being the Gatehouse plant, in which the gasholder was used only for the temporary accommodation of gas prior to metering. This method indicated a manner in which the whole of the error arising in the calibrated gasholder method could be eliminated, because although the gasholder might be filled once or more times during the test, it was brought back to its original position, or datum point, on conclusion of the test. This arrangement, which was of British origin, reduced the error to the meter inaccuracy only. This was very small, but, of course, depended upon the construction and the care exercised in calibrating the meter. By following the lead of Gatehouse one could easily adapt the working of various forms of the closed system type of apparatus to eliminate the error due to the calibrated gasholder.

His personal opinion was that the volumetric method could never give results as accurate as those of the gravimetric method, but with care in preparing and weighing the samples, and special care in calibrating the meter at frequent intervals, the accuracy of the results would come well within the permissible error in either the British Acetylene and Welding Association's or any other regulations.

Speed of Determination favours Volumetric Testing.

The great advantage of the volumetric method was the speed with which the tests could be carried out, but it would always give results applying to gas containing water vapour, which must be corrected for, in addition to the usual correction for temperature and barometric pressure, before the results could be compared with those obtained by the gravimetric method. The question of speed of testing raised the point as to how quickly calcium carbide decomposed in water, and this was a very important factor, not only in testing but in large generating plants. The advantages of a normal rate of generation were obvious, as were the disadvantages of too slow or too rapid generation. Various methods of testing the speed had been suggested; the speed of generation would become a very important factor in the use of calcium carbide in the very near future, and not only would it be necessary to make provision for

testing the speed of generation, but manufacturers of calcium carbide as well as generator designers would have to give attention to it.

Mr. Stephenson made the following suggestions:—

(1) That the standard form of testing apparatus for determining gas yield could be either of the gravimetric or volumetric types, both of which could give accuracies within the errors allowed by the regulations.

(2) Where accuracy was preferable to speed the gravimetric method offered an advantage.

(3) For routine testing and rapid esfimation the volumetric type of apparatus was to be preferred, but the meter, and not the gasholder, should be the means of measuring the gas. For routine tests, as in a carbide factory, where it was essential to maintain a minimum rather than to ascertain the values of gas yield above a minimum, the calibrated gasholder was convenient provided it was of the right type and the gas was properly cooled before it entered. The meter could then be used as a check on the calibration at regular and frequent intervals.

Apparatus for Large Scale Testing.

The type of apparatus for a central testing laboratory should include both systems, and the volumetric apparatus should be provided with means for indicating speed of generation. The regulations should be revised so that amongst other things they could include a specification and standard for more than one quality of carbide being imported and marketed. He suggested at least three qualities, *i.e.*, the present grade, and a higher and a lower grade, because in his experience, whilst there were many consignments of carbide which fell below the present 4.8 cub. ft. standard, and, therefore, should be sold at a proportionately lower rate, there were many which were above the standard to a sufficient extent to command a better price if the means were available for their gas-yielding qualities to be ascertained and classified.

He also suggested for the consideration of the Council, that it might be an advantage to encourage further investigations into the speed of generation and means for measuring it, and that consideration might be given to a paper on the different methods of arriving at the impurities of acetylene when tested.

DISCUSSION.

The President said that the Association had had its regulations under consideration for some time. The question of the International standard for carbide had arisen at the last two international congresses, and since the last congress it had been raised again at a meeting of the Permanent International Committee, and the adoption of the standards of this country was being considered.

Mr. C. S. Milne said he gathered that, of the volumetric systems of measuring, the one Mr. Stephenson favoured was that involving direct metering from the generator, and he would like to know, in that case, how provision was made for alteration of pressure due to rapid or slow generation—whether the meter was capable of dealing with the gas sufficiently rapidly that there was never any pressure building up behind it. He also asked whether it was not necessary to use some form of recording thermometer, so that variations in the temperature of gas passing through the meter could be taken, and allowance made for that in the final calculations. Mr Stephenson appeared to have shown that by far the simplest and most accurate method of measurement was the gravimetric method, and it would appear that if the Association could do something towards getting down on paper some regulations or recommendations as to methods of testing, it would be very helpful to the industry as a whole.

Mr. A. G. C. Lucas, as Treasurer of the Association, said that whether the researches suggested by Mr. Stephenson to make provision for further grades were carried out by the Association itself, or by co-operation with the acetylene associations in other countries, ways and means would have to be provided, and he urged, therefore, the importance of an accession of membership to the Association. He asked Mr. Stephenson whether he thought it best for the Association to make its own researches, or to wait for such conclusions as might be arrived at by the International Bureau, assuming the Association became a contributor to that Bureau.

Mr. Albert Hoddle asked if Mr. Stephenson was satisfied that a carbide yielding a quantity of gas in excess of that specified by the Association's regulations—300 litres—was desirable, having regard to the generators at present on the market. He knew of one instance in which complaints were made as to the yield from the carbide sent to this market by a Continental factory. An effort was made to improve the yield, with the result that the carbide was hardly usable, at any rate, for lighting purposes.

Mr. Stephenson, replying to Mr. Milne's suggestion, in regard to metering devices, that he (Mr. Stephenson) had a preference for the apparatus in which there was no gasholder, said he had no preference for that. He regarded it as purely a laboratory type of apparatus, requiring great care and precision in operation. The meter had a fairly wide range, so that as generation speeded up the meter speeded up. There was a limit to the speed at which it could work, however, so that one must be careful to adjust the water feed so that there was not excessive generation. He agreed with the suggestion to use a recording thermometer on the meter. The gravimetric method was no doubt accurate, but not necessarily the most suitable. Replying to Mr. Lucas, he said there was no need for further research to enable us to find out whether we were getting carbide yielding 4.8 cub. ft., or more, or less. Referring to the cost of research, he said he had no use for communal research; it must be of a personal and private character if one were going to get any benefit out of it. In the case of communal research for the benefit of everybody, many people's views had to be taken into consideration before the results could be published, and it was difficult to be impartial. He agreed with Mr. Hoddle that higher gas yields, or even lower gas yields, were not suitable for all generators, but there was more than one type of generator on the market.

There was an informal dinner before the discussion of the Paper, in accordance with the usual practice. It was attended on this occasion by two Honorary Members of the Association—Sir Aston Cooper-Keys and Mr. Thorn—to whom a hearty welcome was extended.

Prudent Speculation.

By "Onlooker."

Last year's boom in industrial shares galvanised every "bucket shop" in the country into feverish activity. Hence the title of this little article, for "Prudent Speculation" was the title of a fearful and wonderful brochure which reached me through the post the other day. Out of curiosity, the writer read it, and consigned it to the flames! But the title will serve.

The non-ferrous metal markets have always been a happy, or perhaps it would be truer to say, an *un*happy hunting ground for the speculator, and as long as warrants in copper and tin can be bought and sold by the public, for just so long will fingers be burned and bank balances depleted. The psychological aspect of speculation is more a subject for the "Lancet" than for a trade paper, but, broadly speaking, market plungers may be divided into those who are too greedy and those who are not. A second classification would embrace the man who learns the hard lesson of trying to get rich quick and he who most emphatically does not!

Speculation is not a good thing, but it is not so wholly black as it is often painted, for a short spasm of it, though not provocative of sound sleep, teaches a market operator more about the vagaries of metals than a year's perusal of journalistic reviews. There is just about the same difference as between studying "Bridge for Beginners" and making a fourth when the other three are old hands and the stakes too high to be comfortable! Seeing is believing, and to the mind unversed in the pitfalls of speculation in metals it is hard to realise that £500 can vanish almost as quickly as the conjurer's rabbit!

The successful speculator is, of course, a man of courage and sound judgment coupled with a capacity for preserving his view point in the face of market sentiment completely adverse to his opinion. Let it be remembered that profits from speculation are usually made out of the false optimism or pessimism of other people. The exaggerated rise on a "frothy" market or the panicky selling which suggests the end of all things are golden opportunities for the astute operator to snatch a quick profit. That profit is very rarely secured by hanging on to the last penny, and, in fact, 90 per cent. of gambling losses in commodities are suffered because operators want the last ounce of profit out of every transaction.

Speculation has always been regarded as a means of getting rich quickly, and occasionally it may prove to be so, but the prudent operator knows that only once in a way is the time ripe for reaping a speculative harvest. Months may elapse without the combination of circumstances which make the opening of a bull or bear account worthy of serious consideration, but it is nevertheless necessary to watch developments very closely. High and low limits are well worth deciding upon, and the well-known saying that copper under £60 is always worth buying was proved correct during the concluding months of last year. The speculator profits from excited markets, but your over-excited market usually means temporary loss of sanity among "punters," and as this kind of madness is undoubtedly infectious, "safety" points fixed when judgment is cool are of paramount value.

It is notorious that a market always *looks* strongest at the top of a rise, and after a big fall sentiment is always in favour of still greater reductions. Experience shows that excessive speculation in either direction produces a state of affairs very similar to an overstretched spring, and the ability to sense that abnormal condition, with the courage to profit by it, means a certain profit, for the reaction is as sure as sunrise. Patience is undoubtedly a powerful weapon in the speculator's armoury, and the ability to wait without losing faith in a preconceived view of the course of events is equally essential to success.

Speculation teaches self-reliance, and goes a long way towards implanting that sixth sense which whispers words of wisdom to a buyer when market "pointers" are hardly discernible. Is it essential, then, to brave the dangers of a speculative plunge in order to acquire first-class experience? Not altogether, although sooner or later most people connected with non-ferrous metals find themselves involved in a "flutter." Most people have views, more or less decided, on the course markets will take, and are usually ready to give reasons for the opinions they hold. Why not constitute yourself your own broker and buy or sell *on paper* a hundred tons of copper or tin? If the market goes against you, cudgel your brain as to whether you cut your loss and clear out or whether an averaging policy is a better move. Just make a note of the reasons which prompted your various operations and put the "speculative" documents away in a drawer for a couple of months. At their next appearance you may find yourself picking up a handsome profit or facing a staggering loss (on paper!), but in either case you will have learnt a little more of the vagaries of non-ferrous metals.

American Foundrymen's Association New Officers.

The Nominating Committee of the American Foundrymen's Association has put forward the name of Mr. S. T. Johnston (Vice-President and General Manager, the S. Obermeyer Company, Chicago, Ill.) forthe office of President for the next year. Other nominations are:—Vice-President, Mr. Fred Erb (President, Erb-Joyce Foundry Company, Detroit, Mich.). Directors, to serve three-year terms each:—Mr. S. W. Utley (Vice-President, Detroit Steel Casting Company, Detroit, Mich.); Mr. L. W. Olson, Works Manager, Ohio Brass Company, Mansfield, Ohio; Mr. B. H. Johnson, Works Manager, Cresson-Morris Company, Philadelphia, Pa.; Mr. Peter J. Krentz, Vice-President and Works Manager, Buffalo Foundry & Machine Company, Buffalo, N.Y.; and Mr. C. E. Hoyt, Executive Secretary, A.F.A., Chicago, Ill.

Non-Ferrous Research Activities Outlined.

At yesterday's and this morning's meetings of the Institute of Metals a number of Papers were presented having a bearing on non-ferrous foundry practice. Their scope is indicated by the following brief abstracts:—

THE DETERIORATION OF LEAD CABLE SHEATHING BY CRACKING AND ITS PREVENTION.

By S. Beckinsale, B.Sc., and H. Waterhouse, M.Met.

The phenomenon of the cracking of lead cable sheathing had received little attention until recently, when the problem has been studied in America and Germany as well as in this country. The authors of the present Paper have examined large numbers of cables with cracked sheaths, and have considered the positions in which they failed The cracks were found to be intercrystalline, had commenced on the inside of the sheaths, and were generally free from corrosion. The lead in the region of the cracks was not distorted.

Definite evidence was obtained that where lead sheathing failed by cracking, the cable was in a state of vibration. Alternating stress tests on lead and its alloys in the Haigh machine indicated that lead has a very low fatigue limit, and the fractures obtained in the pure lead test pieces were similar in all respects to those found in failed cable sheathing. The conclusion was, therefore, reached that the cracking is a fatigue type of failure.

The addition of other metals to lead greatly raised its fatigue limit, and amongst the most effective additions is cadmium. The properties of certain ternary lead alloys containing cadmium have been investigated, and their high fatigue limit (more than three times that of lead) and resistance to oxidation and corrosion, make them very suitable for cable sheathing which has to withstand vibration.

Explanations other than the above which have been advanced to account for the cracking have also been investigated. These included the presence of deleterious impurities in the lead, overheating during working, abnormal grain size, allotropic change, intercrystalline corrosion, and prolonged tensile stress. Of these only two, intercrystalline corrosion and prolonged stress, might cause intercrystalline cracking in lead, but cracks produced by the former are associated with much corrosion product, and by the latter with much deformation of the lead.

THE DILATOMETRIC STUDY OF LIGHT METALS.

By Max Haas, Dr. Ing. (Aachen, Germany).

Improvements in the Oberhoffer-Esser dilatometer are described, with special application to the study of light metals.

THE THERMAL AND ELECTRICAL CONDUCTIVITY OF SOME ALUMINIUM ALLOYS AND BRONZES.

By Ezer Griffiths, D.Sc., F.R.S. (Teddington) and F. H. Schofield, B.A., B.Sc. (Teddington).

Two groups of alloys were investigated:—(1) Those rich in aluminium, with nickel, magnesium, iron, zinc, manganese, or silver as second or third constituents; (2) those rich in copper, with tin, zinc, lead, manganese, or aluminium.

The aluminium alloys were found to possess a thermal conductivity of roughly 70 to 80 per cent. that of pure aluminium, whilst the bronzes range from one-fifth to one-tenth of the value for copper. In contrast with the pure metals the alloys all give considerable increase of thermal conductivity with temperature.

A comparison of two bronzes of identical composition, except for the presence of a minute amount of phosphorus, shows that the latter produces a marked lowering of the thermal conductivity. The lowering of the conductivity of copper due to an admixture of 10 per cent. of aluminium is comparable with that due to the same amount of tin.

Of the aluminium alloys tested, the 8 per cent. copper and the 4.5 per cent. copper showed the highest conductivity, amounting to 82 per cent. that of pure aluminium. The lowest thermal conductivity of the series was given by a 13 per cent. zinc, 3 per cent. copper alloy, which had a conductivity of 64 per cent. aluminium.

The ratio of the thermal to the electrical conductivity in the range 80 to 300 deg. C. obeys Lorenz's law with one or two exceptions.

THE CONSTITUTION OF THE ALLOYS OF MAGNESIUM AND ZINC.

By R. Chadwick, B.A. (Cambridge).

This Paper contains the account of an investigation of the equilibrium diagram of the magnesium-zinc system. Both thermal and micrographic methods have been used, the system having been investigated at all compositions and down to 200 deg. C. The metals form two intermetallic compounds, $MgZn_2$ and $MgZn_5$, and all four solid phases:—Mg, $MgZn_2$, $MgZn_5$, and Zn, have been shown to form solid solutions. A summary is given of the method of analysis of the alloys, in which the magnesium and zinc are precipitated separately as pyro-phosphates from the solution of mixed chlorides.

HISTORICAL NOTE ON DENSITY CHANGES CAUSED BY THE COLD-WORKING OF METALS.

By Hugh O'Neill, M.Met. (Manchester).

Priority for the observation that its density decreases when a metal is cold-worked is generally attributed to certain Continental workers, notably to Spring (1891). It appears that Berzelius (1844) may previously have noticed the effect, but it is certain that Charles O'Neill, of Manchester, published a careful research upon the subject thirty years before the work of Spring was printed.

THE BEHAVIOUR OF METALS AND ALLOYS DURING HOT-FORGING.

By W. L. Kent, Ph.D. (Birmingham).

Small cylindrical specimens of pure metals and some brasses were forged with a standard blow of 50 ft.-lb. at temperatures up to the melting-points, and the mechanism of hot forging was investigated by measurements of the degree of compressions produced and by comparison of the Brinell hardness values so obtained. The following conclusions were drawn:—

(1) That although the forging test does not measure the malleability of a metal or alloy, it will indicate the relative forgeability at different temperatures, and also the liability for cracking to occur during the operation. It appears that if the working properties of a metal or alloy are to be determined by ordinary mechanical tests, then the joint results of forging and notched-bar impact tests will give the best approximation to the truth.

(2) When a metal is worked at elevated temperatures it strain-hardens in much the same way as at normal temperatures, but not to the same extent. The degree of strain-hardening in copper decreases progressively, but very slightly, as the temperature is raised to 550 deg. C. (Recrystallisation commenced at 600 deg. C. and was complete at 650 deg. C.)

(3) That continuous hot-forging is in some cases made possible by the very rapid recrystallisation and consequent softening of the material, as, for example, copper; but in some cases the actual softness of the metal at elevated temperatures is an aid to hot-forging, as, for instance, aluminium, where rapid recrystallisation does not occur and there is a residual hardness even after forging at 650 deg. C. The progressive decrease in strain-hardening postulated above for copper is probably greater in the case of aluminium.

(4) The forgeability of 70:30 brass increased but little up to 750 deg. C., but that of 60:40 brass increased steadily between 400 deg. C. and

Dr. W. Rosenhain, F.R.S.
The Newly-elected President of the Institute of Metals.

600 deg. C., and very rapidly from that temperature to the melting-point. The presence of lead caused cracking from 350 deg. C. upwards, but in 60:40 brass the cracks disappeared at 700 deg. C., and the material containing lead produced a better forging than the pure alloy.

SEASON-CRACKING OF SMALL-ARMS CARTRIDGE CASES DURING MANUFACTURE.

By F. S. Grimston, C.I.E. (Simla, India).

A short history of the failure of small-arms cartridge cases in India during the past 21 years is given, together with a description of a number of experiments which ultimately led up to the discovery of the probable cause. In 1913 certain experiments were carried out, but without producing any important results.

A recurrence of the defect in 1924 necessitated another series of investigations. A short description of the important operations on the brass case and drawings of these operations are given. Until recently burst cases have been attributed to inferior metal, but it is shown from these last experiments that the defect can be reproduced by certain combinations of the tools used in the drawing operations. Season-cracking in the walls of the case take place during the interval between a drawing operation and the subsequent annealing under certain conditions. The conditions are:—(*a*) The existence of differential stresses in the case wall caused by tools of wrong design; and (*b*) storage of the unannealed cases in contact with soapsuds which have become contaminated with dilute sulphuric acid used in the cleaning processes.

The first portion of this Paper deals with the attempts made to ascertain the existence of internal stress by inducing season-cracking by means of chemical action, whilst the second portion describes certain methods used to detect surface tension in the walls of the cases by measuring the contraction which takes place after removal of the inner supporting metal. Certain definite conclusions are reached. Illustrations are given of the dies used, and of cases showing season-cracks produced in the manner described in the Paper.

THE BALL HARDNESS AND THE COLD-WORKING OF SOFT METALS AND EUTECTICS.

By F. Hargreaves, A.R.S.M. (Ashford).

It is shown for a number of soft metals and eutectics that the relation between diameter of impression and duration of loading is given by the equation $d = ct^s$, where d = diameter of impression, t = duration of loading, and s and c are factors which vary in certain ways.

Temperature of testing is shown to be of great importance, and the total inadequacy of the Brinell hardness figure as a general method of expressing the hardness of soft metals is demonstrated. It is suggested that the ball hardness of soft metals is expressed as in the following example:—Tin (10 mm./100 kg./30 secs./15 deg. C.), Brinell hardness $5.3\ s = 0.050$. The effect of *rate* of loading is briefly considered.

It is found in all the cases examined that the effect of work is to increase factor "s," and it is suggested that in the case of pure metals it is a measure of the rate of spontaneous annealing. The work softening of some eutectics is investigated, and it is shown in the case of the lead-tin eutectic that the rapid fall in Brinell hardness between 20 and 30 reduction in thickness is coincident with the rapid increase in the rate of spontaneous annealing of the main constituent tin.

MINUTE SHRINKAGE CAVITIES IN SOME CAST ALLOYS OF HETEROGENEOUS STRUCTURE.

By W. A. Cowan, B.A. (Brooklyn, U.S.A.).

Minute shrinkage cavities in certain heterogeneous alloys are described in this Paper as due to shrinkage, accompanying change in volume between liquid and solid phases, of a relatively low freezing-point component, where it last freezes after the bulk of the alloy has solidified at higher temperature.

As an instance of this, some tin-base alloys are shown to contain minute shrinkage cavities when small percentages of lead are present, but to be practically free from similar cavities with no lead content. The main component of the alloys described is solid solution of antimony in tin, which solidifies at 237 deg. C., while the component present in small amount, being the eutectic mixture with lead, solidifies at a lower temperature (183 deg. C.), thus producing minute shrinkage cavities. Photographs are shown to illustrate this.

An examination of the microstructure of the alloys containing some lead shows cavities located at eutectic areas, probably between crystalline grains, while similar alloys without any lead content show no cavities. Cavities in cast metals are formed by a number of different causes, and their occurrence should be correctly assigned to the actual causes, and instances of shrinkage recognised as such.

NOTE ON THE COMPOSITION OF OLD ROMAN LEAD.

By W. A. Cowan, B.A. (Brooklyn, U.S.A.).

Reference is made to composition of old Roman lead found in England, as previously reported by Friend and Thorneycroft. Analysis is given of a specimen of old Roman lead pipe found in Rome, dating from A.D. 79, showing it to be of similar composition to that found in England.

Jobbing Patternshops.

Attention has been focussed recently on the importance of the jobbing patternshop in the engineering cosmos. Twenty or twenty-five years ago there were many jobbing patternshops in which very inferior work was done. Patterns were made that, superficially, had the appearance of being well finished, but frequently they had to be taken to pieces, as no consideration had been given to moulding difficulties. The experience with those early jobbing patternshops has made many engineering firms reluctant to place any patternmaking work with outside firms up to the present day, but there are many shops now where patternmaking of the very best kind can be obtained. Twenty years ago, with one or two exceptions, the jobbing patternshops in this country were ill-equipped with machinery and were run almost entirely by boy labour. The necessity for competing with customers' own patternshops has forced jobbing patternmakers to equip their shops with the most modern woodworking machinery, and also to employ skilled labour.

Owing to no overhead charges and careful organisation it is often possible for an engineering firm to have patterns made outside at much less cost than in their own works. Thus, for many small firms, there is no need whatever for them to equip a patternshop and employ men who may be without work for a considerable part of each week. This remark applies equally to those firms specialising in repetition work and to the repair engineer who may require a pattern for one casting.

It is probable that the jobbing patternmaker buys his material at lower prices than many large engineering firms, as the proprietor is his own foreman in most cases, who adopts the most economical methods of construction, and he can often pick up quantities of good timber at very cheap prices.

In a shop with a good run of work there is no waiting time between the finishing of one job and the beginning of another. Until a few years ago there were probably more jobbing patternshops in London and the Midlands than in all other parts of the United Kingdom. The reason for this was largely due to the number of small engineering concerns, but during the past ten to twelve years there has been a steady development of the practice of placing patternmaking outside the engineering works, and even in marine centres there are some very large patternshops. We know of some such patternshops in the Clyde area that are employed almost entirely on marine work. Sometimes it is convenient for an engineering firm with its own patternshop to place the foundry work in the hands of a jobbing patternmaker whose workshop may be adjacent to the foundry that supplies the castings, and this may be much more economical than for the firm itself to employ one or two men whole time at the foundry.

Co-operative Patternshops.

The jobbing patternshop that has a steady stream of work coming in can employ men regularly and these men have every opportunity of acquiring great skill, because of the variety of the work that is contracted for. It is rather surprising that the co-operative type of patternshop has not been more generally adopted. We know of one patternshop that was established by several firms, and these firms supplied it with enough work to keep it practically fully employed, although work was also sought from other firms. In all engineering centres there are numbers of small firms that could very profitably equip a shop with the most modern plant where their work could be executed at much less cost than in their own works, where they would probably require to have a foreman and several machines with only one or two men employed.

Although the best customers for jobbing patternshops are the small engineering firms who have no patternshop of their own, yet when trade is good there are many large firms that find it convenient to place work with outside firms rather than work systematic overtime or employ night shifts. The quality of the work done depends very largely on the price that is paid for it. There has been considerable price cutting in the business and if a firm is forced to take work on at an unremunerative figure, then unwise economies are going to be adopted both in regard to material and constructional methods. Costing patterns is always exceptionally difficult because many little things may happen during the course of construction and no two men work at the same speed. The patternshop in this respect is unlike engineering machine shops, where the rate of production depends almost entirely on the speed of the machines. For high class work where standard patterns are wanted from which perhaps hundreds of castings would be made, it is much wiser, if the patternmaker proves himself to be trustworthy, to place the work on a time and material basis. This is not a very usual practice, but there is no reason why it should not be adopted, and jobbing patternmakers have too many competitors to act unscrupulously. It can be said that in very many cases better timber is employed in the jobbing shop than in the average engineering works patternshop, because it is recognised that cheap timber is not an ultimate economy, involving as it does much more labour to finish it.

J. M.

New Companies.

R. A. Bradshaw & Son, Limited.—Capital £15,000 in £1 shares, to acquire business of ironfounder carried on by R. G. Bradshaw at Carr Foundry, Albert Road, Retford, Notts., as R. A. Bradshaw & Son. Directors: R. G. Bradshaw (chairman), Meed House, Retford; Mrs. Beatrice H. Bradshaw, Meed House, Retford; R. W. Spencer, Woodstock, Retford. R. G. Bradshaw, permanent governing director and chairman. Secretary: R. W. Spencer.

Cotterill & Company, Limited.—Capital £100 in £1 shares. Cutlers, forgers, metal stampers, spinners, etc.

Croft Cutlery Forging Company, Limited.—Capital £3,000 in £1 shares, to acquire business of cutlery forgers carried on by R. E. Skipwith and R. W. Roberts at 53 and 55, Garden Street, Sheffield, as The Croft Cutlery Forging Company. Directors: R. E. Skipwith, Ruddington, Notts.; R. W. Roberts, "Fern Bank," Endcliff, Rise Road, Sheffield; and G. L. Latham.

William Hamilton (1928), Limited, Glen Yard, Port Glasgow, Renfrewshire.—Capital £200,000 in £1 shares, to acquire the business of William Hamilton & Company, shipbuilders, Port Glasgow. Directors: Sir James Lithgow, shipbuilder; H. Lithgow, shipbuilder; Sir A. Brocklebank, shipowner; Sir Percy G. Bates, shipowner; A. C. Francis Henderson and D. S. Lawrie.

Hollow Steel Floor Company, Limited.—Capital £1,100 in £1 shares. Managing directors: G. D. Cochrane, The Box, Nunthorpe, Yorks; J. H. Southern, 41, Newcomen Terrace, Redcar.

Insurance Engineers, Limited, 20-22, Lincoln's Inn Fields, W.C.2.—Capital £30,000 in £1 shares, to undertake control, management or supervision of engineering business of any insurance company, etc.

Institute of Metals.

ANNUAL MEETING.

The 20th annual general meeting of the Institute was held yesterday at the Institute of Mechanical Engineers, Storeys Gate, when the President, Sir John Dewrance, inducted his successor, Dr. Walter Rosenhain, F.R.S., into the chair.

The Council's report for the year ended December 31, 1927, is one for congratulation, and the perusal of the following abstract shows that excellent progress is being made:—

REPORT OF COUNCIL.

The Institute has increased in status, in membership, in financial resources, and also in the extent of its library and office accommodation. The Institute's "housing problem" was very urgent a year ago, and stress was laid upon it in the last Report. How the need for additional house room has since been met is shown subsequently in the present Report.

Roll of the Institute.

The number of members on the roll of the Institute on December 31, 1927, was as follows:—Honorary members, 4; Fellows, 2; Ordinary members, 1,792; Student members, 105; total, 1,903. The growth in the membership of the Institute during the past five years is indicated by the following figures:—1923, 1,532; 1924, 1,571; 1925, 1,692; 1926, 1,801; and 1927, 1,903.

The Council records with regret the decease of the following members:—A. Alexander; F. W. Gower; H. Heape; Sir James Kemnal, J.P.; H. V. McKay; Sir Gerard A. Muntz, Bart. (past-President, 1910-1912); Richard Pearce, Ph.D. (Member of Council, 1908-1909); and C. R. Wood.

The Council has, during the year, elected Sir Ernest Rutherford, O.M., F.R.S., a former May Lecturer, as an honorary member, and Sir William E. Smith, C.B., a former Vice-President and chairman of the Finance and General Purposes Committee, as a Fellow.

General Meetings.

Three general meetings were held during the year. At the first of these—the annual general meeting, held in London on March 9 and 10—seventeen papers were presented. The seventeenth annual May lecture was given in London on May 11 by Sir Henry A. Miers, F.R.S., on "The Growth of Crystals in Supersaturated Liquids." The autumn meeting was held at Derby on September 6-9, when thirteen papers were presented, and visits were paid to works in the locality.

The Council has under consideration the desirability of arranging further foreign meetings. A Committee has been appointed to explore this matter. The views of members with regard to meetings held outside Great Britain would be welcomed by the Council.

Journal.

Two volumes of the "Journal," Volumes XXXVII and XXXVIII respectively, were issued, these containing 1,699 pages. In view of the rapid growth in membership of the Institute and of the demand for "Journals" from outside sources, the printing order for the volumes has been increased to 3,000 copies. The receipts from sales of volumes during the year reached the record figure of £1,215.

Much attention has been devoted by the Publication Committee to the possibility of increasing the value of the "Journal" by the publication of more practical papers and abstracts. To this end letters were addressed on the subject of practical papers to all members of Council and officers of the Local Sections. As a result, several practical papers have been received or promised. The Abstracts Section of the "Journal" has also received the close consideration of the Publication Committee, which has decided to curtail certain sections that were felt not to be of general interest to the membership, and to amplify other sections that had wider appeal. An entirely new section will appear for the first time in the June issue of the "Journal" dealing with "The Finishing of Metals and Alloys."

The Council accepted, with regret, the resignation, as chairman of the Publication Committee, of Dr. W. Rosenhain, F.R.S., who had been chairman of the Committee for the past ten years, as his coming Presidential duties would render it impossible for him to hold the two offices. As his successor, Dr. H. Moore, O.B.E., was appointed.

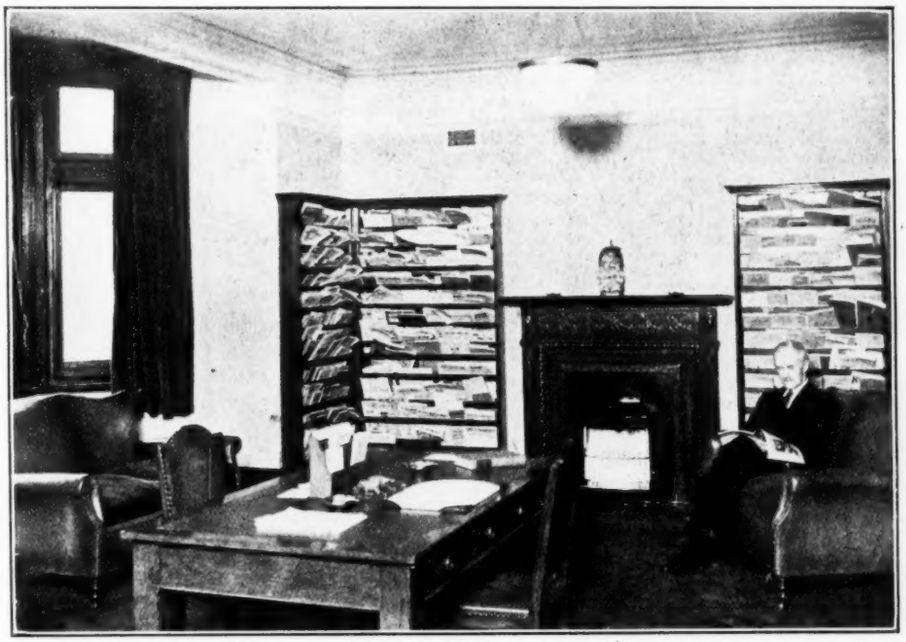

FIG. 1.—READING ROOM, SHOWING RACKS FOR CURRENT ISSUES OF PERIODICALS.

Local Sections.

The six Local Sections of the Institute continued their good work during the year. A notable feature of the meetings of these sections was that many were held jointly with other kindred societies. An Appendix to this Report contains a list of the current session's papers and the names of the chairman and honorary secretary of each section. In accordance with the new Articles of Association the Council, for the first time, exercised its power to co-opt a chairman of a Local Section as a member of Council, the choice falling upon Mr. A. H. Mundey, chairman of the London Local Section.

Membership Development.

Active steps were taken during the year with the object of raising the Institute's membership to 2,000 during 1928—the twentieth year of the Institute's existence. By December 31, 1927, a total of 1,903 had been reached as compared with 1,801 a year previously. It is hoped that members will assist the Council during 1928 in the endeavour to raise the membership to 2,000. The Council would direct attention to the extent to which the Institute's membership has now become world-wide. Whereas ten years ago, out of a total membership of 888, only 200 resided overseas (in 25 countries), the 1927 total of 1,903 members included 700 overseas members resident in 41 countries. It is gratifying to note that the Institute's work is so widely appreciated, and the Council is glad to encourage this interest on the part of overseas members. Members in Great Britain, however, should not fall behind in bringing the value of the Institute's work to the notice of individuals who would benefit thereby. The rapid growth in the overseas membership shows the extent to which those at a distance, and not in a position to participate in all the Institute's activities, value its work.

Corrosion Research.

A programme of work with the new apparatus for large-scale laboratory tests was started at the beginning of the year, and has been proceeded with continuously. The tubes tested include various types of 70: 30 brass and Admiralty alloy tubes, several compositions of cupro nickel, and a few special alloy tubes.

The results so far are difficult to interpret, owing to unforeseen factors which have been in operation. Of these a very troublesome one has been the variation in corrosive properties of the sea-water used. Supplies of water taken in the autumn appear to have been considerably less corrosive than those taken in the spring and early summer. Sea-water from the same source has been used for many years without such variations having been noticed previously. The reason is at present not clear. During the progress of the tests a careful study has been made of the conditions in the apparatus, particularly those which appear to control the types of attack associated with the impingement of rapidly moving sea-water. A considerable amount of new information regarding this form of corrosion has been collected.

Arrangements have been made to increase the capacity for carrying out tests on a large laboratory scale. Two additional sets of apparatus are at present under construction.

For the purpose of studying more closely some of the conditions observed in the larger apparatus, a new form of jet-test apparatus has been designed and is proving useful for many purposes.

Considerable progress has been made in the development of a new electrical method of studying the formation and breakdown of the protective films which form on the surfaces of condenser tubes in contact with moving sea-water. A test of the method on tubes, the behaviour of which is known from previous experiments, has given encouraging results. In certain cases there appears to be good agreement between the electrical properties of the protective film and the known behaviour of the tube. An interesting fact, which has been brought to light by this method, is that the protective film which forms naturally on certain tubes may have definite self-healing properties in the event of local injury to the film. This property appears to be particularly well developed in certain special tubes of recent manufacture. The same method also appears to have

possibilities for the investigation of changes in the corrosive properties of the liquid.

During the year a number of cases of corrosion in the condensers of ships and power stations have been investigated and have given interesting information.

Valuable assistance to the Investigator, Mr. R May, A.R.S.M., has been rendered by Mr. G. H. A. Jenkinson, A.R.S.M., and subsequently by Mr. A. F. B. Norwood, A.R.S.M, during their temporary appointments as assistant investigators.

Library.

The Council is glad to be able to report that during the year it was found possible to carry out a scheme that has been projected for many years —but hitherto impracticable owing to lack of funds—whereby the Library might be enlarged and a full-time trained librarian appointed. The new Library, which is well-stocked with up-to-date metallurgical books and periodicals, has been placed under the charge of Miss E. B. Wynburne, B.A. It is hoped that the new arrangement, together with the provision of a telephone in the Reading Room, will enable still greater service to be afforded to members. Certain books that are not contained in the Library can now be obtained on loan for the use of members from the Science Museum at South Kensington. This is a most valuable new facility. Members are reminded that they can borrow books or periodicals from the Library by post. The full development of the Library is still hampered by lack of funds, and the Council would welcome donations to the Library Fund or the gift of books.

Offices.

The Council is glad to be able to report that the long-needed expansion of the Institute's office accommodation was made possible during the year. an adjacent suite of rooms (on two floors) having become vacant. Thus the accommodation available has been more than doubled.

The Council would record with gratitude the receipt during the year of several gifts of furniture, these including a Council Room table and carved oak chairman's chair (both the gift of the Honorary Treasurer, Mr. John Fry), and also a clock for the Library, the gift of an anonymous Member of Council. The cost of furnishing the new offices has been largely defrayed from accumulated interest in the House Fund, together with a small surplus resulting from the Derby meeting.

Representation.

The Institute was represented by Dr. W. Rosenhain, F.R.S., at the International Congress for Testing Materials, held at Amsterdam in September. As a result, a "British Committee for the New International Association for Testing Materials" has been set up and the Institute has been invited to appoint a representative on that Committee. Dr. Rosenhain has been appointed as the Institute's representative.

The Second (Triennial) Empire Mining and Metallurgical Congress—of which the Institute is a constituent body—was held in Canada, the Council being represented by Professor D. Hanson, D.Sc.

At the Werkstoff Kongress, held in Berlin, and at the subsequent meeting of the Deutsche Gesellschaft für Metallkunde, the Institute was represented by Dr. R. S. Hutton.

Other Conferences held during the year at which the Institute was represented were those of the Royal Microscopical Society, held in Liverpool, Professor C. O. Bannister, M.Eng.A.R.S.M., being the Institute's delegate, and the Conference of the Association of Special Libraries and Information Bureaux held at Cambridge, at which the Secretary represented the Institute.

As the Institute's representatives upon the Beilby Memorial Fund Committee the President, Treasurer, and Secretary (*pro tem.*) were appointed.

The report is signed by Sir John Dewrance, the President; Dr. Walter Rosenhain, Vice-President; and Mr. G. Shaw Scott, Secretary.

Fig. 2.—A Corner of the Council Chamber.

Combine of the Italian Iron and Steel Industry.—"With the exception of the Società Acciaiere e Ferriere Lombarde of Sesto San Giovanni, near Milan, all the iron and steel works in Italy have formed a cartel to control prices, which are to be reduced to meet foreign competition." This report published in English and Continental papers last week is not borne out by statements from the leading manufacturers in Rome. They point out that a consortium is in existence for the purpose of regulating the sales of steel in Italy, but that this was not a cartel in the generally accepted meaning of the term. They also point out that the consortium was formed some time ago and that it had been renewed when the previous term expired last January.

Iron and Steel Institute.

Autumn Meeting in Spain.

As previously announced the autumn meeting of the Iron and Steel Institute will be held in Bilbao, from September 24 to October 3, 1928, by invitation of the members resident in Bilbao and the neighbouring district. An influential reception committee has been formed under Don Alfonso de Churruca (Chairman) and Don Luis Barreiro (Hon. Secretary).

Two sessions for reading and discussing Papers will be held at Bilbao. The subsequent arrangements will include visits and excursions to the iron and steel manufacturing and engineering establishments and to the principal iron mines in the neighbourhood of Bilbao, as well as excursions to places of historic interest. Plans are also in progress for making an extended tour in the days immediately following the meeting. The itinerary will include a journey to Madrid, with a break of a few hours at Burgos, sight-seeing at Madrid and excursions to Toledo and the Escurial. A special invitation is also extended to members by the managers of the Compañia Siderurgica del Mediterraneo, to visit the new iron works at Sagunto. Further, for the convenience of any who may desire to prolong their stay in Spain, arrangements will be made to convey them to Seville for a stay of three days.

Subject to revision, the main party of members travelling from Great Britain will leave London (Victoria Station) by special train on the morning of Friday, September 21, and will spend the night in Paris (Hotel Palais d'Orsay). On Saturday, September 22, they will proceed from Paris (Gare d'Orsay) by an early special train, reaching Irun (Spanish frontier) about 9 p.m., and San Sebastian about 10 p.m., where they will be accommodated in first-class hotels (Hotels Maria Cristina, Continental, and Londres) for Saturday and Sunday nights.

Members not taking the Seville tour will be able to leave Madrid for Hendaye (French frontier) on October 3, spend the night at San Sebastian and travel on to Paris the next day. Or they can proceed direct by night train to Paris, and return to London on October 4 by any service that may be convenient to them.

The estimated rates from London back to London vary from £33 to £89, according to number of excursions, but are at present provisional. The railway charges are based on the assumption that the number of individuals travelling to Bilbao, and also the number travelling on to Madrid, is sufficient to form the complement of a special day train on each section of the journey, say, 200 persons. If the number of participants falls appreciably short of 200, the fare will be subject to some increase. For the night trains Madrid—Sagunto—Madrid, and Madrid—Seville—Madrid, the prices include sleepers, but they are calculated on the basis of 80-96 persons. Further particulars as to the itinerary and estimated inclusive charges may be obtained by members on applying to the Secretary (28, Victoria Street, Westminster, S.W.1).

An Invitation to London Foundrymen.

Members of the London Branch of the Institute of British Foundrymen are specially invited to the next meeting of the London Local Section of the Institute of Metals to be held on March 15, in the rooms of the Society of Motor Manufacturers and Traders, Limited, 83, Pall Mall, W.1, when Mr. Wesley Lambert will give an address on "High Tensile Manganese Bronze Casting Alloys."

Russian Ferro-Manganese.—The Harriman concern is about to put up a plant at Poti for the manufacture of ferro-manganese under the terms of their manganese ore mining concession. The necessary iron ore is to be obtained from a deposit recently discovered in the Tshatakliski district.

Presidential Address to the Institute of Metals.

Dr. W. ROSENHAIN, D.Sc., F.R.S., ON EQUILIBRIUM DIAGRAMS.

In beginning this address, my first desire is to express my deep sense of the honour which you have done me in electing me President of the Institute of Metals. There is, to my mind, no higher honour which could be conferred upon a metallurgist interested in non-ferrous metals. The honour is particularly gratifying to me, because to a considerable extent I feel that it is conferred upon me as representative of two great things—things far greater than any personal achievement. The first is the metallurgical research organisation which I have the honour to superintend at the National Physical Laboratory. Whatever metallurgical achievements may be put to my credit now or hereafter, I can only regard as the fruit of the enthusiastic co-operation of a band of research workers who have helped and inspired me quite as much as I have ever been able to inspire or guide them. The second is metallurgical research itself. Several previous Presidents have been eminent for their metallurgical researches, but they have either been University professors or industrial research workers. In the present instance, however, you have honoured in this signal manner research activity pure and simple. Moreover, that research activity has not been confined by any means to the non-ferrous metals, but has ranged over the entire field of physical metallurgy, and to that extent you have recognised a principle to which I am deeply attached—the solidarity of metallurgy, whether non-ferrous or ferrous.

The late Sir Gerard Muntz.

Before passing to the main subject of my address, I would like to pause a moment to honour the memory of a most distinguished Past-President whose sudden death occurred a few months ago. Sir Gerard Muntz, bearing a name historically associated with British non-ferrous metallurgy, was appropriately the second President of this Institute. His vigorous personality and personal charm are fresh in our memories, and so is his long and loyal service to the Institute. As a leader of industry he was most appreciative of the value of science and of its practical applications. The Institute is proud to have his name on its list of Past-Presidents, and owes him a very real debt of gratitude.

When a "scientific" President assumes office in this Institute, I feel that there may be some fear, among a section of our members, that the Institute will become more scientific—more "high-brow" than ever. I should like to allay that fear, if possible, by saying that no one will welcome more than I do papers of practical interest dealing with practical subjects. There is no function of this Institute which I value more highly than that of promoting interchange of ideas and experiences between practical men and between practical and scientific men who are interested in the same subject. The Institute has done much to break down barriers that formerly hampered the progress of the non-ferrous metals industry. Men, both practical and scientific, have come to know and understand one another better, and with increasing mutual knowledge has come that measure of confidence which is essential if men are to work together profitably. I only wish that it might be possible for that understanding and confidence to grow not only deeper as between the technical man in the works and the scientific man, but that it might grow wide enough to embrace also the business man—the man who, ultimately, controls finance, and therefore is the deciding factor in determining how far and how soon the results of research are to be utilised. Even in that difficult direction the Institute has done something, and will, I hope, do more in the future.

High-Brow Papers Represent Pioneer Work.

Meanwhile, criticism is sometimes heard of the large number of scientific papers which are discussed and published by the Institute, and of their comparatively unintelligible nature for all except the trained scientific specialist. Something can, perhaps, be said in defence of these papers; they often deal with the very frontiers of our knowledge and embody the results of real exploratory or pioneering work. It is by no means easy for the scientific worker, who has to think hard and work hard on strictly accurate scientific lines, to adopt, in presenting his results, non-technical language which is almost unavoidably vague and often inadequate to express what he has to tell. However, while these advanced scientific researches on metals and alloys are most important, they are not directly the concern of the practical man. Provided the practical side is adequately represented in the publications of the Institute, the practical members should not, I think, grudge the time, space, and money which are devoted to the scientific aspect of the subject. It must be remembered that the world-wide reputation of our Institute rests largely on its essentially scientific work.

There is, however, between the entirely practical, dealing with the details of works processes and methods, on the one hand, and the entirely scientific on the other, a large field of what should be common ground to all our members. The difficulties of practical metallurgy at times seek, or at least need, scientific assistance to overcome them, and scientific results are brought to the point of practical application. There is, of course, no hard-and-fast boundary to this common ground—indeed, it is the work of this Institute to widen it as much as possible. Where it is reached depends on the sense of practical things on the part of the scientific writer and on the power to appreciate scientific results on the part of the practical man, and both these powers are larger than we are apt to suppose, and can be considerably enlarged. It is to a small attempt in that direction that I propose to devote this address.

Equilibrium Diagrams.

One of the features of our Journal which sometimes provokes the good-natured criticism of our practical members is the frequency with which "equilibrium diagrams" occur. Perhaps I have myself been one of the sinners in this respect, either in person or through a number of my colleagues. The first paper which I contributed to the Institute at its first meeting in Birmingham in 1908 dealt with this subject—*i.e.*, with "The Metallographic Investigation of Alloys," and related largely to the methods used in the determination of equilibrium diagrams. It will not be inappropriate, therefore, if in this address I attempt to give something in the nature of an explanation—even a defence—of the equilibrium diagram—an explanation and defence which are not required by the scientific metallurgist, but are addressed essentially to the practical man who may perhaps care to know why these things are determined, what they are, and how they can be applied to practical purposes. And although I have said that such an exposition is not needed by the scientific man, I make no apology for introducing it to the members of one of the most scientific metallurgical institutes in the world, because it is not a bad thing, even for the most scientific worker, to pause at times and consider the nature and possible practical utility of the work on which he is engaged.

Strength Graphs.

Like many other scientific terms, the name "equilibrium diagram" appears forbidding to the uninitiated. In reality, it is quite simple. Let us think of an alloy system—that is, a series of alloys made by melting together two metals in various proportions—and let us, for the moment, think of simple alloys which contain only two metals. At first sight it would seem that to study those alloys we must examine each of them, make mechanical and other tests, and record the results in tables. Then, however, we find that we shall appreciate our results better if instead of merely recording our results in tabular form, we try to represent them by a curve or graph. There is, obviously, a very simple way of doing this. We draw a base line whose length we divide into one hundred parts, and we can then use distance along this line to represent the composition of the alloys. In a direction at right angles to the base line we can plot the data for our alloys. Thus we might plot tensile strength in tons per sq. in., using any suitable scale, and if we join the plotted points we obtain a curve or graph indicating the relation of tensile strength to composition right through the alloy system. Such a graph tells us something more than the disconnected figures in a table. It indicates, to begin with, the approximate properties of alloys of composition intermediate to those actually made and tested. This is not always a safe indication if we do not know more about alloy system, but when we do know more—that is, when we have an "equilibrium diagram" before us—then this kind of deduction, which in scientific language is called "interpolation," is entirely safe; this is, in fact, one of the very real uses of these diagrams.

The graph of tensile strengths, further, may indicate the general way in which the strength of the alloys varies according to their composition, and the indication that there is a maximum value somewhere between two points already determined may serve as a guide to finding the best alloy of a series. A great many graphs connecting the various measured properties of alloys with their composition have been constructed and, taken by themselves, furnish results which are often anomalous and difficult to understand. The properties do not vary continuously, nor do they all vary in the same or even in a corresponding manner. The alloys, in the great majority of cases, do not follow the rule of simple mixtures in which it is easy to calculate the properties of the mixture by the simple addition principle from the known properties of the ingredients. Obviously, if we want to understand our alloys and to control their properties in a rational way; if we want to make and use the best possible alloys for each specific purpose, or even to know what will be the effect of slightly varying the composition of a well-known alloy, we must seek to understand these irregularities and anomalies. These things are not accidental but follow exact laws and rules, and it is important for practical work with alloys to know those rules.

Treatment Modifies Properties of Alloys.

The position, when we come to study practical alloys, is still further complicated by the fact, well known to every practical man, that the properties of an alloy of given composition are not entirely fixed by the composition, but depend upon the treatment which has been given to the material. Whether the alloy has been slowly cooled in a large sand mould or rapidly cooled in a metal chill, whether it has been forged or rolled while hot, or drawn while cold, all affect the final properties to a marked extent. Sometimes, too, we find large and in themselves unexpected difficulties in melting an alloy if we change its composition slightly. Thus aluminium alloyed with 3 per cent. of iron is entirely fluid at a temperature of 750 deg. C., but if we increase the iron content to 10 per cent., the alloy is not completely melted until a temperature of 950 deg. C. has been reached. Here, again, we should suspect, even if we did not know, that there must be rules or laws behind these apparent irregularities, and again it becomes desirable to know and to understand those rules in order that we may not grope blindly for our desired results but march to them along a well-defined road.

Introduction of Metallography.

These irregularities of alloys which, if we were not so familiar with them, we might describe as "mysteries," naturally attracted the attention of research workers, and it is now some sixty-eight years ago since the first effort to solve these mysteries on modern lines was made by the application of the microscope to the examination of metals. The beautiful methods of microscopic metallography were developed, first by Sorby in Sheffield, and later by a succession of workers, among whom the names of Roberts-Austen, Osmond, Martens, Stead, and Arnold will always be remembered. At first, practical men were in-

clined to scoff at these new methods. The area which can be examined at one time under the microscope or represented on a photomicrograph is so minute that it was urged that conclusions drawn from it could not be applied to masses of metal weighing perhaps tons. In view of the importance which is rightly attached to microstructure to-day it is surprising to find these adverse views expressed in all seriousness in the discussion of one of the earlier "Alloys Research Reports" presented to the Institution of Mechanical Engineers not so many years ago.

Simple Alloy.

Study of the microstructure of alloys soon showed that there is a close connection between the microstructure and all the physical properties. One type of alloy has a comparatively simple structure, very similar to that of a pure metal: it consists of grains or, as we now know, crystals which are all alike in chemical composition, but differ from one another only in orientation—that is, in the direction of the lines on which each crystal is built up. All the alloys that show this type of structure have a certain similarity of properties, although that is a relative way of looking at them. There are, for instance, wide differences between an alloy of copper with 10 per cent. of zinc and one of aluminium with 3 per cent. of copper; yet both are alloys of this simple "single constituent" type. None the less, the aluminium alloy just mentioned has a much closer resemblance to the copper-zinc alloy than it has to another alloy of its own system containing, say, 30 per cent. of copper. The two former alloys are both ductile and forgeable, although to widely different degrees; they both have relatively good tensile strength and ductility. The aluminium alloy with 30 per cent. of copper, on the other hand, is extremely brittle and weak. This is just one example of the fact that the structure of an alloy may have as profound an effect on its properties as its composition itself.

Duplex Alloys.

Passing on from our first simple type of alloy in which there is only one kind of crystal, we come to what are called the "duplex" alloys—that is, alloys consisting of two different constituents. Here we find several different types, and again there is an intimate relation between microstructure and properties. So far, indeed, does this connection go that it can be relied upon to a considerable degree of accuracy not only in otherwise unknown alloy systems of two metals, but even in alloys of three, four, or more metals. In a recent investigation carried out at the National Physical Laboratory, it was desired to find an alloy possessing a particular property in the highest possible degree. Preliminary exploration showed that these properties were only approached when the alloys showed a certain type of duplex structure—*i.e.*, a particular arrangement of two microscopic constituents. Further search through a very wide range of compositions was therefore made, purely on the basis of examining the microstructures of small specimens of the alloys and preparing on a larger scale for purposes of mechanical testing only those which showed the right kind of structure—a proceeding which led rapidly to the desired result.

There are, of course, many features in the microstructure of alloys besides the simple or duplex constitution which have a direct bearing on the properties of the alloy; but I need not go into those here; we may take it as established that there is a close connection between the microstructure and the properties of our alloys. Microstructure does not readily lend itself to plotting in the form of graphs. None the less, we could construct charts of our alloy systems, indicating not only which constituents are present for each composition, but also the amount of each of these types of crystal. This has been done and is instructive, but it is only subsidiary to the construction of another kind of chart by which we can represent our alloys in a much more complete and logical manner.

If the connection between microstructure and properties of alloys is accepted—as it must be, in view of the mass of evidence that supports it—then our next question, in seeking for an explanation of the properties of alloys, is to ask what is the nature of these micro-constituents and how are they formed?

Nature of Micro-Constituents.

This is by far the most difficult of the questions which we have so far considered. The full answer to it cannot even yet be given for all alloys and for all methods of treatment, but it can be given with certainty and clearness for the great majority of the alloys with which we are concerned in practice, and that answer is, simply, the equilibrium diagram. For the constituents of any alloy, at all events in its initial cast state, are formed either direct from the solidifying alloy or, subsequently, during cooling, by the interaction of the substances which are already present in the alloy. Much, as we know, depends on the rate of solidification and of cooling, and subsequent heating and working may produce further changes, but we need not allow these complications to confuse us in any way, for again there is rule and method behind the apparent complexity and confusion, and we find that for any alloy, and indeed for any series of alloys or alloy system, there is always one particular condition which the constituents tend to reach. They do not always reach it, because at low temperatures changes cannot take place, at all events in the harder metals, at any measurable rate. Thus an alloy, once cooled to the room temperature, is to all intents and purposes—fixed—held rigid—in the state in which it happened to cool down from those higher temperatures where changes can and do occur at reasonably rapid rates. It is only if an alloy is held at such high temperatures for a sufficiently long time, or is allowed to cool exceedingly slowly, that it approaches this final condition. But it is still this final condition which all alloys *tend* to approach, and it is in the first place this ultimate condition—this limiting state—which we require to know and to understand. Then only can we approach the more difficult question of determining how far, with a given treatment, and especially with a given rate of cooling, that final state will be approached or departed from.

Transitional Phases.

There is another reason why it is this final, ultimate state of our alloys that we need to study and ascertain: it is the only state which is definite and fixed for each alloy of given composition. Other states are in reality stages of transition. They are extremely important stages, but cannot be properly understood unless we realise that they are steps in a series of transformations or changes which are in some alloys so slow that the final state is never reached in practical working, while in others the final state is closely approached under ordinary working conditions. This final state towards which every alloy tends on cooling is what we call the "equilibrium" condition. It is, for a cooling alloy, exactly what "finding its level" is for water, and just as the interposition of a barrier of varying degrees of porosity, from that of sponge to that of cement, may retard or even prevent the attainment of its equilibrium level by water, so may the internal resistance to movement in an alloy retard or prevent its attainment of the equilibrium structure. It is doubtful whether in our laboratories we ever really attain true final equilibrium in the alloys we study, but we seek to approach this state sufficiently closely to enable us to judge correctly what that final state really is.

Maintaining a Condition of Balance Between Solid and Liquid.

There is just one other point about these "equilibrium" states which it is necessary to bear in mind. As the word "equilibrium" itself indicates, these states are not essentially fixed and unchanging conditions, but rather states of permanent and stable balance. But the precise state in which such final balance will be reached depends on the temperature at which our alloy is maintained. For example, at a high temperature, well above its melting point, the alloy will be entirely liquid, and this liquid will be the condition of "stable equilibrium" under those conditions. What this means will be immediately understood if we think of a piece of the same alloy in the cold, solid state being introduced into the molten mass. Provided that the solid, cold piece is not so large as to chill the whole mass, or that a sufficient supply of heat is available to maintain the temperature in spite of any chilling effect, we all know what will happen—the cold piece of metal will be rapidly heated, and, after a short time, will also melt or be dissolved in the molten alloy. For a short time, and for a short time only, solid and liquid alloy could co-exist, but very soon the balance between them is reached—by the melting of the solid. If, on the contrary, a small quantity of molten alloy is poured into a hole in a mass of the cold, solid metal, the molten material will very rapidly solidify. Here, owing to the low temperature, the balance is on the side of the solid state and the liquid rapidly disappears. It is clear, however, that at some intermediate temperature a condition might be found where the two states, the solid and the liquid, were capable of attaining an exact balance where solid and liquid can exist in a permanent state of balance or equilibrium, and this is actually the case. At the melting point such a state of equilibrium between solid and liquid exists, and so long as the exact temperature required to produce this condition of balance is maintained, so long does this state of equilibrium between solid and liquid continue. A rise of temperature gives the preponderence to the liquid—a fall to the solid.

Principle of the Phase Rule.

Conditions of balance depending on the exact temperature are frequently encountered in alloys. The balance may be produced, as in the example we have been considering, between solid and liquid; it may also occur between solid and vapour, and, indeed, vapour must always be present as a third factor, which has to be considered when the state of balance is to be attained. In the majority of metals and alloys, however, the amount of vapour which can exist at reasonable temperatures is very small and we can ignore it. In some metals, such as zinc and cadmium, and still more in mercury and manganese, the vapour becomes important. Other conditions of balance or equilibrium, however, occur between two or sometimes three different solids, different kinds of crystals, and this balance changes with temperature in a way which is sometimes of great practical importance, as in the hardening of steel or of Duralumin. If, therefore, we wish to understand the behaviour of our alloys and the nature of the various constituents which the microscope reveals in them, we must seek to know as much as we can about the equilibrium or balance conditions which, as already pointed out, are by no means always attained, but which determine the kind of change which takes place at each temperature. In studying these we should, perhaps, find ourselves confused and liable to go far astray were it not that again a guiding principle has been discovered which tells us something about the kinds of balance or equilibrium which can occur in the various types of alloy. This principle is known as the "Phase Rule," and it applies to all systems or mixtures, so that it extends far beyond alloys into solutions and mixtures of all kinds, from the molten magmas which produced the igneous rocks of the earth's crust, to the waters of the ocean or the mixtures in the beakers of the chemical laboratory. This Phase Rule is a kind of fundamental natural law which tells us nothing about the structure and constitution of real alloys, but it does tell us what that constitution must tend to become for given conditions of temperature, composition, and, where vapours are concerned, pressure, if the state of final balance or equilibrium is reached. It tells us, in the form of a simple numerical rule, how many different kinds of bodies can be present at the same time in true equilibrium when the three conditions named above are fixed.

A Phase Rule Analogy.

I have already suggested an analogy between the changes which take place in an alloy during solidification and cooling, and the tendency of water to run downhill and to find its level. We might perhaps consider the very elementary question why water really does run down hill. We know

from the great principle of the conservation of energy, which even the most modern physics has not yet shaken, that whatever happens there can be no real loss of energy. But when water is at a high level it has stored in it a certain definite amount of work—the work done in pumping it up to that level. After the water has run down to the lower level, however, that stored work or power has disappeared, usually in the form of heat, and it is this tendency to release stored-up power or energy and to allow it to become dissipated as heat that is the real motive force in causing water to run down hill. It is a principle we meet everywhere in nature; where work or power is stored up it requires only some method of release—the pulling of the trigger of a gun is a good example—to cause the stored-up energy to run down more or less rapidly. Now the next step we have to take is to realise that in every piece of matter, whether liquid or solid, simple or complex, a certain amount of energy or power is locked up, the amount depending upon the temperature and pressure. But the amount which is thus stored up varies with the nature and condition of each kind of matter, and we can represent this as a kind of pressure, corresponding to the water-pressure or hydrostatic head in our analogy of the water raised to a height. Mathematicians have given to this "pressure" the very general name of "potential."

Energy Potential and Metastable Alloys.

The idea which I wish to suggest to you is that when two or more substances are brought into intimate contact, if their energy pressures or potentials are different there must be an immediate tendency to interchange, if such interchange can lead to a lowering of the average pressure or potential of the whole. This tendency to reduce the energy pressure to the lowest possible level, corresponding exactly to the running of water down hill to the lowest attainable level, is the moving force in all the changes which alloys, and other mixtures, undergo. It is, in fact, by working out the exact way in which this process of running-down of energy—"lowering of the potential"—can occur by changes from solid to liquid or liquid to solid, or from one kind of solid crystal to another, that the simple relation has been derived which we know as the "Phase Rule." Those who read discussions on the constitution of alloys, and on certain chemical phenomena, will know that there are many cases in which it is said that "the Phase Rule is not obeyed." These are cases in which, however, it is supposed that the rate at which the final condition of balance or equilibrium is attained is exceedingly slow—so slow that in practice it can be said that nothing like equilibrium is ever attained. This is true of many alloys. Thus certain alloys of copper and tin, if cooled very slowly, consist of an aggregate of only one kind of crystal, and each crystal is entirely uniform in composition. If somewhat quickly cooled, however, these crystals show the well-known "cored" structure—a structure which is not indicated by the "Phase Rule"—and, indeed, the very fact that it is removed by sufficiently slow cooling shows that it is a transition state and not a state of final balance. Yet an alloy possessing this cored structure which, because it is not truly stable but is yet very persistent, we call "metastable," has been known to exist for thousands of years without losing its characteristic "cored" features. At ordinary temperatures, therefore, the rate at which this alloy tends to attain its true equilibrium condition is to all intents and purposes zero. But it is a real tendency none the less, and one we require to understand, because otherwise we should not understand why this "cored" structure disappears rapidly if the alloy is heated to a suitable temperature.

In the study of alloys which I have so far asked you to follow in imagination, we have discovered a series of inter-connections and regularities, and all or most of these we are now in a position to correlate with a kind of diagram which is not nearly so formidable as it may at first sight appear. If we realise that all the constituents which are found in alloys as features of the microstructure are formed during cooling, it is natural that we should try to chart, in the simplest and most comprehensive manner possible, the various changes which occur in a series of alloys when they cool down from the molten state, and in making such a chart the "Phase Rule" is a most valuable guide. If we begin once more with the horizontal line divided from 0 to 100 to represent the percentage composition of our alloy series, we can plot temperature at right angles to that base line, and on the field thus formed we can insert every change which the alloys undergo. Thus we can begin by finding the precise temperature at which each individual alloy of our series begins to solidify; or, if we have suitable apparatus, we can determine the lowest temperature at which each alloy is completely liquid. If we mark the points thus found we obtain a very important and typical curve which metallurgists have called the "liquidus." Scientific metallurgists are often accused of inventing and using difficult technical terms, of which this word "liquidus" is a good example. But it is, in reality, just a kind of abbreviation. If we want to say exactly what that single word conveys we must say: "The curve joining all the temperatures at which solidification begins or melting is just complete," and if we were obliged to repeat such a phrase whenever there is occasion to refer to that kind of curve, it would make our Papers even longer than they are. It would almost seem worth while for those who are interested in alloys, and who wish to understand what scientific research is discovering about them, to learn the meaning of a few of these special words. After all, the business man uses an elaborate "slang" of his own; such terms as "net," "contango," "E. & O.E.," "F.O.B.," etc., do not, by themselves, convey any more meaning than the words "liquidus" or "phase"; but he would be a foolish man who tried to deal with business matters without learning the meanings of these special terms. The musician, similarly, is allowed a weird terminology of his own. Indeed, we find that every trade and profession develops its own special vocabulary, so that the scientific investigator is not perhaps so very different in what he does, or in what he can scarcely avoid asking of his readers. In this present address I am intentionally avoiding, as far as it is at all possible, the use of these technical terms or abbreviations, and the length at which I am consequently obliged to explain each step of my argument will be evident to those who have the patience to follow it.

Constitutional Details.

Returning to our equilibrium diagram, many other lines can be drawn in it by connecting together various observed points. There are the temperatures of complete solidification on cooling or of incipient fusion on heating, which are connected by a line or series of lines known as the "solidus." Then, generally at lower temperatures, we find changes occurring in the alloys, either by interaction at a definite temperature between solid crystals already formed and the liquid still present, resulting in the formation of a new kind of solid crystal, or by the splitting up of one kind of solid crystal into two kinds. All these changes, and others which I cannot stop to enumerate, can be indicated on the diagram, and when all of them have been correctly inserted we have a complete chart of the various states of balance or equilibrium which alloys of the whole system tend to assume at each temperature and composition.

Accurate Work Essential.

The Paper which I presented to this Institute at the first meeting in 1908 dealt with the methods of studying equilibrium diagrams then in use, and I put forward a plea for work of much greater accuracy, and went so far as to suggest that many of the diagrams then being published would be found, on more detailed study, to be incorrect. I was told at that time that these "rough" diagrams represented exploratory work done mainly for the purpose of discovering the existence of inter-metallic compounds. I had no confidence in the methods used, even for that restricted purpose, and to-day it has been abundantly proved that those rough methods gave in many cases misleading results—misleading even on the very question of the existence or otherwise of compounds. The history of this subject strongly points the moral that even exploratory work must be done with the greatest possible accuracy if it is to yield results of value.

Thermal Analysis.

The methods which have been mainly used in the construction of these diagrams are what is known as "thermal analysis," and the study of microstructures. For the former methods cooling and heating curves are taken, and signs of changes in the alloys are found as arrests or retardations of cooling or heating. This method has been carried to great refinement and still yields fundamentally important results. It requires, however, the study of the microstructure to complete its indications. This is not merely, as the earlier workers used it, the examination of the structure of the solid alloys cooled down to room temperature in a mould or even in the furnace. The true method was magnificently demonstrated by Heycock and Neville in their classical work on the alloys of copper and tin published in 1903. It consists in maintaining specimens of accurately known composition at a definite temperature for a time which is thought sufficient to secure a close approach to the equilibrium condition, followed by rapid chilling in order to avoid the intervention of possible further changes during subsequent cooling. Sometimes, instead of holding the specimen at a fixed temperature for a long time, it is cooled down very slowly to the specified temperature and is then quenched. The methods of Heycock and Neville have been considerably extended and improved, and in their present form afford the best available insight into the changes which alloys undergo, or tend to undergo, at various temperatures, and this information is translated into the well-known diagrams.

Dilatometry.

In addition to these, which may be called the "classical" methods of investigation, others have been developed. A very important one is known by the rather terrible name of "dilatometry"; it consists in measuring by very delicate means the changes in volume, or more usually in length, of specimens of the alloys when heated or cooled very slowly. This method has been developed originally in France by Chevenard, and has recently found extended application, by means of very beautiful appliances, by the late Professor Oberhoffer and by Dr. Max Haas of Aachen, and by many others, including Dr. Griffiths and Dr. J. L. Haughton in this country. Another method which is being widely used, especially in Japan, is the measurement of electrical resistance of alloys at various temperatures. It is, in fact, quite possible to use measurements of any physical property of metals which varies with temperature for the purpose of detecting irregularities which are, or may be, associated with changes in the alloys. None of these, however, appears to me to be so fundamental as the combination of the thermal and the microscopic methods Indeed, there is reason to doubt whether there may not be important changes in alloys which do not make themselves felt in changes of all the physical properties. Each method has therefore its limitations, and it is unwise to attempt, mainly on the strength of one method, to "correct" the findings obtained by another. While there are still some disagreements among investigators concerning a few outstanding questions in regard to certain alloys, our knowledge of equilibrium diagrams has progressed immensely during the past fifteen years, and the majority of them are now known with reasonable accuracy.

Accuracy Shown to be Justified.

Whether this degree of accuracy, or the still higher degree of refinement at which some scientific metallurgists are aiming, is really "worth while" is a question which is sometimes asked, even in scientific circles. In my opinion, there is no doubt that it is very well worth while. I think that this is particularly the case in regard to the study of alloy systems maintained in a state of very high purity. From the scientific point of view this increasing accuracy is desirable, because it will help to bring out more clearly the close inter-relation of different alloy systems. A few years ago it would have been impossible to

predict what kind of equilibrium diagram would be given by the alloys of any pair of metals which had not yet been examined. To-day we can recognise certain regularities in the kinds of alloy systems which are formed, and it may be that, when these systems are still more completely known, further regularities will appear. In the May Lecture which I had the honour to give to this Institute in 1924, I pointed out some of these regularities—they had been recognised by others before me—and I endeavoured to suggest an explanation for some of these features. It cannot yet be said whether those tentative suggestions were right or not; more accurate work alone can carry us forward. The effects of relatively small and perhaps unsuspected impurities can be large enough to render similarities of different diagrams unrecognisable, or even to destroy the validity of a diagram entirely.

Even from the practical point of view, however, the highest degree of attainable accuracy in these diagrams is of much greater importance than would at first sight appear. It is true that industry does not and probably cannot work with extremely pure metals, in the laboratory sense of the word "pure," but an exact knowledge of the effect of each unavoidable impurity is important. This has been recognised by the British Non-Ferrous Metals Research Association, who have afforded my colleagues and myself the opportunity of studying, in a research continued over a term of years, the effects of impurities on copper, and it will be well worth while at a later stage to extend that investigation to the more important alloys. As an example of the way in which impurities may affect the determination of an equilibrium diagram, I should like to quote the case of the alloys of aluminium and zinc. One of the first attempts at obtaining a diagram of this system was made by Shepherd in America, and was very simple. Later, Mr. S. L. Archbutt and I studied this system in connection with the work described in the "Tenth Report to the Alloys Research Committee of the Institution of Mechanical Engineers," and the diagram at which we arrived then (in 1912) revealed a series of lines, representing changes in the alloys, which the rougher methods and probably less pure materials of the earlier workers had missed. This diagram, we were fully aware, was not complete, but we had not the means, or, possibly, the insight, to complete it at that time, and it was only completed later by my two colleagues, Dr. D. Hanson and Dr. Marie Gayler. Some attempts to "correct" this diagram have been made in Japan and Germany, but in each case I believe that the methods used were much less accurate and conclusive than those of Hanson and Gayler. But—here comes the interesting point—the phenomena associated with the changes which these alloys undergo at 256 deg. C. are so striking that they have been repeatedly used for demonstration purposes. On one occasion such a demonstration was to be given, but the alloy prepared for the purpose did not behave as expected—the striking phenomena, in fact, were lost. It was soon discovered that this was due to the presence of a small amount of lead; as soon as pure metals were used the striking phenomena again developed. This little incident serves to show that an important series of changes in this alloy system—changes which are particularly important on account of their analogies with the behaviour of steel and of Duralumin—would have been entirely overlooked, as they were in fact overlooked by Shepherd, if metals of insufficient purity had been used for the investigation.

Scientific guidance to industry demands the very best that scientific methods and resources can produce. It is only the most accurate and advanced work which, I am sorry to say, is sometimes brushed aside as merely "academic," that leads to those far-reaching results upon which our great industrial advances of the future must be based. When, therefore, we see perhaps an entire paper devoted to the exact determination of a single line in one of these diagrams, we should regard that paper in its proper perspective as a valuable contribution—valuable in proportion to its accuracy—to a subject which is fully as important to the practical man as it is to the scientific metallurgist.

Alloying and Its Results.

Let us think of a series of alloys produced by adding increasing quantities of one metal to another, beginning with the pure metal. Let us call it *A*, and add successive quantities of metal *B*. At first, in the great majority of alloy series, the two metals not only mix readily—that is, "dissolve in one another"—when they are in the liquid, molten state, but up to a certain point they remain completely mixed or dissolved in one another even after they have solidified. The microstructure of the slowly solidified alloys tells us this at once, because we find, in such cases, that although there are two metals present, the alloy consists of only one kind of crystal—it is built up of only one constituent. It follows that both metals must be present in each individual crystal. We now know that the atoms of the two metals are built up together on the same plan or geometrical scheme—we call it a "space lattice." This really means merely that the two metals have preserved, after solidification, the same state of intimate mixture which existed while they were molten. We think of the liquid mixture as a solution, and we transfer this idea to the crystal and call it a "solid solution." Similarly, we speak of the extent to which a liquid can dissolve a solid or another liquid as the "solubility";

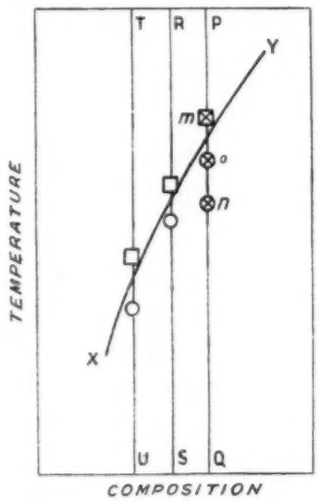

Fig. 1.

more strictly, it is the "liquid solubility." Thus water at 15 deg. C. can dissolve about 20 per cent. of copper sulphate and no more; this is the "solubility" of the copper sulphate in water. If we warm the water it will take up more sulphate, as the solubility rises with rising temperature, so that at 50 deg. C. it becomes 33.6, and we could plot a curve showing the connection between the solubility of the sulphate in water and the temperature. That would be a solubility curve for copper sulphate in liquid water. Exactly similar relations exist in the "solid solutions" which are formed where two metals crystallise together in the same individual crystals. They can, in some instances, do this in all proportions: in such a case, in whatever proportions we alloy the metals, the resulting material will still have a structure like that of a pure metal, consisting of one kind of crystal only. Copper and nickel, silver and gold, are examples of this kind of alloy, but from our present point of view these are less interesting than those in which the power of forming solid solutions is limited, where the crystals of metal *A* can only take up a certain limited proportion of metal *B*, so that, if more *B* is present in the alloy, a second constituent—a second kind of crystal—must be formed. The alloys of lead and tin, of aluminium with copper or with zinc, of copper with tin or with zinc, are familiar examples of this type. That is a metallurgical fact which has long been known, and it has important consequences. Particularly where the second kind of crystal is not the pure or nearly pure second metal, but some intermediate substance, either a chemical compound of the two metals or some intermediate type of solid solution, that second constituent is always harder and more brittle than the simple solid solution. The second constituent of brass, generally called the β constituent or phase, which makes its appearance when more than about 30 per cent. of zinc are present, is a good example. The presence of this second harder constituent markedly changes the properties of the alloys: they become stronger and stiffer, but also less ductile, the effect becoming more marked as the proportion of the second constituent increases. In alloys of the "brass" type it is possible to correlate very closely the mechanical properties with the proportion of the second or β constituent.

The most interesting and important results, however, have only come to light from the study of the exact limits of solid solubility. This simply means tracing out, over a wide range of temperature, from that of complete solidification down to room temperature or lower, the exact amount of the second metal which can be present in the alloy without the appearance, after sufficiently slow cooling, of a second kind of crystal. This determination is not easy. Thermal curves give no useful indication, and even dilatometry and measurements of electrical resistance are not entirely reliable. The most reliable results, however, are obtained by the microscopic method. In principle this is simple. In the diagram, Fig. 1, let the vertical line *PQ* represent an alloy of given composition. Let us first heat it and maintain it accurately at the temperature indicated by the point *m* for a long time—long enough to ensure that it will either have taken up into the main crystals or rejected from them anything that is likely to be taken up or rejected. This time is sometimes very long, and we can only find out how long it needs to be by making successive trials and finding whether or not a longer exposure has made any further difference. When the specimen has been held at the desired temperature long enough, we chill it as rapidly as possible. Then we examine it under the microscope in order to ascertain whether a second constituent is present. This requires careful and practised observation, but with care quite small quantities of a second constituent can be detected. Suppose we find that in specimens quenched from the temperature of the point *m* there is no trace of a second constituent. We next heat the same or another specimen of the same alloy at the temperature of the point *n*, considerably lower than *m*, and again quench and examine. This time, perhaps, we find quite an appreciable amount of a second constituent and we try a third specimen, heated at and quenched from an intermediate temperature like that of the point *o*. Here we find on microscopic examination the merest traces of the second constituent, and we are justified in concluding that the limiting solubility lies between the points *m* and *o*. If, now, we repeat such a series of experiments with alloys of the compositions represented by the vertical lines *RS* and *TU*, we will find for each of these lines two points, fairly close together, between which lies, for each alloy, the point of limiting solubility—*i.e.*, the point at which, in each alloy, the structure changes from that of a simple solid solution to that of a "duplex" material showing two constituents. As the alloy cools through this point, if it cools slowly enough, some of the second metal is rejected by the crystals of the solid solution, and this rejected portion forms a new kind of crystal.

Limiting Solubility Curve.

If we consider a whole series of alloys, we can draw a line connecting those points of limiting solid solubility and thus obtain our "limiting solid solubility" curve, like the curve *XY* in Fig. 1. Such a curve, although it conveys scientific information, does not appear of obvious practical importance, but in reality it has proved to be very important. In various alloy series these solubility curves take widely different shapes. In a few systems they appear to be very nearly vertical, and sometimes they lie very near the line which represents the pure metal. That means, in the first case, that the solubility of the two metals in one another does not change as the alloy cools, and in the other that there is very little solid solubility—*i.e.*, that the range

of possible solid solutions is very short. Where the solubility curve slopes, as it does in Fig. 1, towards the pure metal side of the diagram with falling temperature, it means that at a high temperature it is possible to produce a solid solution containing a larger amount of the dissolved metal than can be dissolved or kept dissolved at lower temperatures. Such cases are fairly frequent, and we now know that they imply particularly interesting properties in the alloys concerned.

Now let us consider a concrete example from the aluminium-magnesium-silicon diagram. This is really equivalent to the diagram of a series of alloys of two simple metals, except that the place of the second metal is taken by a well-defined intermetallic compound, Mg_2Si, to which, for brevity, we may refer as "silicide." Let us consider the alloy containing 99 per cent. of aluminium and 1 per cent. of silicide, as indicated by the dotted vertical line *PQ* in Fig. 2. If we heat this alloy at 550 deg. C. and quench it, we find a simple solid solution structure, since we have quenched it from a temperature above the solubility curve. If, on other hand, we either allow it to cool down slowly, or quench it from any point below the solubility line, we find a duplex structure—the second constituent, which in this case consists of crystals of magnesium silicide, can be seen in the microstructure.

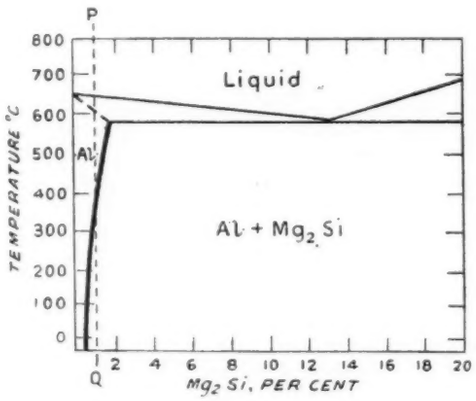

Fig. 2.

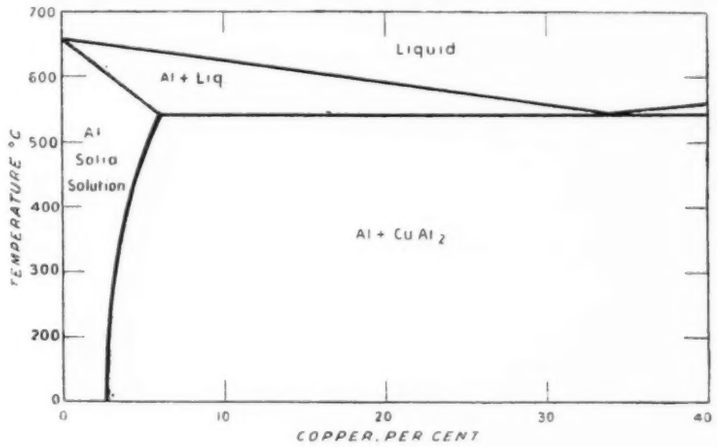

Fig. 3.

Influence of Quenching.

Now let us consider the specimen quenched from the higher temperature. It has been brought down to the room temperature so rapidly that the second constituent has not had time to separate, and the alloy exists, when thus treated, as what we may fairly describe as a "supersaturated solid solution"—*i.e.*, it is a solution in which each crystal holds a larger number of silicide atoms built up in it than corresponds to normal equilibrium at room temperature—and there is, consequently, a strong tendency for things to right themselves, for changes to occur which tend towards the equilibrium condition. In some such cases, at room temperature, nothing will occur, because the internal rigidity of the crystals is so great that no movement can take place. In the aluminium alloys, however, conditions are fortunately not so rigid, and we find that, slowly, changes take place even at room temperature, although even here they are quickened very much if we heat the quenched alloy slightly. These changes consist in the gradual decomposition of the supersaturated solid solution, and the separation, in an extremely finely divided form of the excess of magnesium silicide from the aluminium matrix. This separation (we may well describe it by the chemist's term "precipitation") of extremely fine particles of silicide throughout the aluminium solid solution crystals causes profound changes in their internal arrangement, and these changes bring about a gradual hardening of the alloy. This, in fact, is what is now fairly generally accepted as the mechanism of the well-known age-hardening of Duralumin and similar alloys. The alloys of aluminium and copper behave in a very similar way, except that they do not readily undergo this decomposition process of "age-hardening" until they are heated to something like 150 deg. C. When Duralumin is allowed to age-harden at room temperature, its hardness is due essentially, if not exclusively, to the precipitation of magnesium silicide from the supersaturated solid solution, while if it is aged at slightly elevated temperatures it is the separation of the aluminium-copper compound $CuAl_2$ which is mainly responsible for the effect.

Age Hardening.

It was, I think, something of a metallurgical triumph to have solved the mystery of the age-hardening of Duralumin in this way. The ingenious German discoverer, or inventor, of the alloy frankly admitted that he did not understand why it underwent these changes, which are vital to its usefulness. But the discovery of this process of age-hardening meant something far greater than the explanation of the mysterious behaviour of any one alloy or type of alloy. It was clear to those who appreciated what the discovery meant, that age-hardening must be possible for *any* alloy lying in the range of a solubility curve which slopes in the same way as that of the silicide, or of copper, in aluminium. In any such alloy it should be possible to produce a supersaturated solid solution by quenching and then to produce hardening by subsequent "ageing," either at room temperature or at a higher temperature. And this prediction has been realised already in a number of alloys which have been or are being put upon the market. Unfortunately, the patent law permits those who exploit this discovery in regard to specific alloys to obtain patents for those alloys, while the original discovery, with all that it meant, was given freely to the world by British and American investigators.

A High Tensile Beryllium Alloy.

The principle having first been established for a group of aluminium alloys has been applied to other alloy series of that metal, so that we now have a number of aluminium alloys or alloy groups capable of undergoing age-hardening in varying degrees. These are well known under proprietary names which I do not propose to advertise. Some of them, containing both zinc and manganese, I would point out, are anticipated by alloys described in the "Eleventh Report to the Alloys Research Committee of the Institution of Mechanical Engineers" in 1921. More recently the application of the principle has been extended to alloys of copper. Curiously enough here, too, the element silicon plays an important part, since one of the alloy types which yield valuable results on quenching and ageing at a moderately high temperature is that consisting of copper alloyed with both nickel and silicon. These age-hardening alloys of copper are as yet new and by no means fully developed, but they represent an important development in non-ferrous alloys. Alloys consisting mainly of copper and retaining most of the advantageous properties of that metal, and combining it with degrees of hardness and strength which, if previously attained at all, required the presence of a large proportion of complicated alloying metals, cannot fail to make their impression in regard to engineering uses. In this connection notice must also be taken of the alloys of copper, and possibly of nickel, with some of the rarer elements. Alloys with beryllium have recently been shown and described in Germany which appear to possess truly startling properties as the result of the application of this process of age-hardening after quenching which I have described. In one of these alloys we have probably the most striking example of age-hardening yet known, since its Brinell number can be raised from 80 to 410, and a tensile strength of over 90 tons per sq. in. can be attained, although unfortunately this extreme degree of hardening is accompanied by an almost complete loss of ductility.

Equilibrium Diagram and Future Developments.

It may be that some will ask of what use are these discoveries of new and remarkable alloys to the ordinary manufacturer or founder of brass and bronze—how do they help him to make cheaper or better castings, or sheet or tube? The answer to that question lies in two widely different directions. The first is, perhaps, the more consoling, since it is to suggest that although this particular aspect of metallurgical research may not be of direct benefit to those important branches of non-ferrous manufacture, there are others which offer direct benefits even to those old-established activities. I have, after all, dealt only with one example of the usefulness of equilibrium diagrams, and one example could not be expected to apply to many branches of industry. The second part of the reply to that supposed question may, perhaps, be somewhat disturbing. Is it quite certain that our age-old products, "ordinary" brass and bronze, will always be able to maintain their position? They owe that position to their superiority for certain purposes, and from certain points of view, to iron and steel. But that position is already threatened in some directions by the advent of the rust-resisting steels and iron alloys. In another sense it may be still further threatened by the advent of age-hardening alloys which may combine a greater resistance to corrosion with physical properties resembling those of steel, or even exceeding them. If that should be the case, even to a limited extent in the future, it becomes a matter of vital importance to the non-ferrous manufacturer to keep himself well abreast of such developments and not to leave the results of British discoveries to be exploited and patented abroad. These things may not help him to make better and cheaper brass and bronze as we know them to-day, but they may enable him to make in the future non-ferrous alloys that can hold their own with the best products of research as applied to iron and its alloys. This is no battle between "ferrous" and "non-ferrous," but friendly rivalry in the progress of both to the benefit of industry and of science also.

A Note on Marine Patternmaking.

By James Edgar.

It is doubtful if any other section of engineering patternmaking is more costly in relation to the price of the finished article than in marine-engine shops and shipbuilding yards. In motor-car shops the pattern in point of first cost may be expensive, but hundreds of castings will be made from it. Even in machine-tool shops the same patterns may be used over and over again, but in shipbuilding yards a large proportion of the patterns are only used for the production of one or two castings and are then scrapped. It is rather surprising that no attempt is made to reduce patternmaking charges by reusing the timber of which the patterns and coreboxes are constructed. Many large barrels, boxed-up pieces and coreboxes could be very quickly dissembled by unskilled labour, and the timber retrieved could be used as conveniently for making into new patterns as new timber obtained from the racks.

For any class of engineering, patterns are expensive, and the proportion of the total cost of the propelling machinery of a vessel that is expended in patternmaking is very high indeed. In the ship-repair pattern shop the work may be of a rough order, but there is plenty of scope for ingenuity in devising makeshifts. A question that is often discussed by engineers is whether or not it is profitable to use old castings as patterns. Old patterns, except for pipe work, can seldom be used advantageously in repair shops, one reason being that it is very seldom indeed that castings of similar design are wanted twice, and this applies equally to boiler, engine and deck work. Old castings, even when there are intricate cores, can often be used as patterns, core prints being added where necessary, and undercut parts being also cored off. A point that does not always receive attention is whether or not it is desirable to strengthen new castings by increasing the thickness of metal or by additional ribs. A careful examination of a fractured casting will often disclose the weakness. When a casting fractures in service, either there has been a foundry defect or the design has been at fault, and in most cases a modification of the design is necessary. When old castings are used as patterns it is generally found necessary to make new coreboxes, although this can be obviated in some cases by having an old casting sawn in two. In the repair shop there are more patterns made to templates instead of drawings than in shipbuilding yards, and the reason for this is obvious; when a vessel is drydocked for overhaul all the work has to be done at top speed, and there is therefore no time to make drawings. Further, workshop drawings, if they are necessary, can equally as well be made by patternmakers as by draughtsmen. Although the ship-repair pattern shop may not be a good place for a boy to serve his apprenticeship, because accuracy is often sacrificed to speed, yet it is a splendid shop for a young journeyman to obtain experience.

Marine patternmaking methods differ from that for other types of engines and for machine tools. Machine tools are generally standardised, and locomotive cylinders are comparatively small, and although not made on a repetition basis, yet it is seldom that only one or two locomotives are ordered, while it is rare for a shipbuilding firm to obtain a contract even in normal times for more than two vessels. There are marine-engine builders on the Clyde, the Tyne and elsewhere who standardise engines for small and medium-sized tramp vessels, but we have in mind at the moment vessels of the passenger liner class. The patterns for these standardised engines are of the highest quality, and are modified over and over again.

Cylinders, bedplates and column patterns for marine engines require much timber in their construction, and the labour charges are fairly high. There is a considerable amount of valve and pipe work that must be made from templates which have to be fitted "to place." In some shops this practice of making "to place" is done more extensively than in others, but the most careful laying-out of an engine room cannot obviate template work altogether. Even when some patterns are made from drawings they have to be taken to the ship and checked in position.

In many large shipbuilding yards there are two pattern shops. One of these does all the work in connection with the propelling machinery, while the other, called the yard pattern shop, is responsible for patterns used in the construction of the hull, deck fittings and hawser pipes. These two shops are in most cases organised as quite separate departments, and constructional methods that are suitable for engine patterns may not be most economical for deck fittings. For deck fittings and many other jobs of the yard pattern-shop accuracy is not as important as appearance.

It is sometimes disputed as to whether it is or is not advisable to have all the patternmaking done in one shop, but in nearly all cases when there is only one pattern shop it has been found necessary to divide it into two departments, one of these being for engine work and the other for yard work. It must also be remembered that in nearly all shipbuilding yards there are the two distinct sections, yard and engine works, under the control of separate managers and having separate drawing offices.

Each shop has its own stock of timber, and in this regard it is often wrongly assumed that low-priced timber is cheap. When a pattern will be used to obtain one casting only, the best quality timber may not be necessary, but, on the other hand, if, owing to windshakes and knots, 25 per cent. of the timber is cut to waste, there is no saving. It is profitable to grade patterns. Even in marine shops there is much standard valve work. Patterns for such valves should be constructed of good timber; in all probability there will be no important change of design for years, and the pattern will be used, it may be, for brass and iron, although this is not usual, over and over again.

In some shops patterns of the flimsiest kind are made, and in some shops strickles are more common than patterns. It may be admitted that for reciprocating-engine cylinders or turbine casings the construction need not be of so permanent a kind as for valve work, but it is doubtful if many of the makeshifts resorted to are really economical. Thus an improperly-constructed pattern may mean a reduction of patternmaking costs but higher labour charges in the foundry.

Cheap patterns in many cases necessitate the almost constant attendance of patternmakers at the foundry, and accuracy is not as certain. Thus a badly-constructed pattern may not only involve higher foundry costs, but also additional work on the castings in the machine shop. Patternmaking methods in the case of large work depend to a great extent on the tackle which the foundry has for castings production. There are foundries in shipbuilding districts that will not build loam moulds or use skeleton patterns, and others that prefer these to solid patterns and coreboxes. A cheaper price may be quoted by a foundry that insists on more expensive patterns, and then the higher patternmaking costs will be more than recovered. Engine-room alterations, apart from repairs, are common, and if new valves or pipes are wanted, templates must be made which dispense altogether with drawings. We have seen long ranges of pipes fitted right across engine rooms that were made from templates. One important advantage of templates is that they can be used as guides in the machine shop when bolt holes are being drilled in flanges.

Crossley Brothers, Limited.—Criticism of the fact that no dividend has been paid for some years was made at the annual meeting of the shareholders at Manchester on February 23. Sir Kenneth Crossley presided. In moving the adoption of the annual report, Sir Kenneth said that any appreciable difference in the figures during the past year was in the right direction. "The only question I can anticipate is," he said, "why no dividend on the ordinary shares? I can assure you that our parsimony in this direction gives us no pleasure, but it is purely a matter of finance. Speaking generally, I feel more confident in our old company than I have felt for some years." The motion was passed, and Major Eric Crossley, the retiring director, was re-elected.

Slag.

By Practicien.

"Slag"—the scoria from a smelting furnace or volcano. That is the interpretation of the word as set down by recognised dictionaries. Many of us, however, are quite content to leave it at that and have neither patience nor interest to analyse the subject in detail. Maybe this is due to the fact that cupola slags seem to be of little or no importance and any time spent on carefully studying this "residue" would appear a comparative waste of valuable time. Such a supposition is entirely wrong, and for one utterly to ignore the slags brought down at every "blow" is futile, as only indifferent results will be obtained from the cupola, unless one is exceptionally fortunate. There are three things which can indicate much when the various slags obtained are studied—(*a*) weight, (*b*) colour, (*c*) appearance.

Heavy Slags.

Should the slag be a very heavy one, the blast pressure and the amount of limestone (or other flux) should be immediately investigated. A heavy slag invariably denotes the presence of iron. In many case the iron is found in the form of spherical pieces of iron embedded in the slag. This is commonly known as shot-iron. Such an irregularity is caused by chilling of the molten metal in the "blast zone." A high blast will accelerate such an occurrence and more so when insufficient charges of coke are made. Occasionally one gets a heavy slag with the blast, flux, coke charges, etc., theoretically correct. Such a thing, however, can only be due (in the above case) to the slag hole having been left open. An insufficient charge of flux at each mixing often contributes to shot-iron and consequently heavy slag.

The Colour of Slags.

When one examines the numerous slags obtained from different cupolas, it is really most interesting if not surprising how many different shades and colours are found. Jet black, white, light yellow, bottle green, blue and brownish red are the chief colours encountered. At once we ask, which colour denotes the most efficient results in melting? Such a question can hardly be correctly answered, for different irons produce different slags. For example, an iron high in manganese tends to produce slags of a yellowish tint, but, speaking generally, a slag of bottle-green colour can be taken as an indication of really good melting. An excess of limestone at each charge is liable to show itself in the resulting slag, being of whitish colour, whilst black and slightly blue slags mean the presence of iron oxide—a matter demanding immediate attention. Thus we see that although the colour and appearance of slag is only a semi-guide, it often indicates defects which hitherto may have taken weeks to find out had no attention been paid to the slag. Always keep the slag hole clear, for if the hole is of correct dimension the flow of slag will regulate itself and flow freely with quick cooling and without chilling.

In conclusion, it may be interesting to note that several foundries use their slag for making road beds. It is said to be ideal for roads which have not to deal with exceptionally heavy traffic.

Personal.

Mr. George W. Vickers, Mr. David M. Anderson and Mr. Alex. Williamson have been elected special directors of Vickers-Armstrong, Limited.

Mr. J. Reay, late manager of the Malleable Works of the South Durham Steel and Iron Company, Limited, has been the recipient of handsome presentations from the officials and men.

Wills.

Wheeler, E., Old Hill, Staffs, iron, steel and metal merchant £1,558

Smith, J., of The Grange, Saughall Massie, Cheshire, senior partner in the firm of Robert Smith & Sons, metal merchants, Cleveland Street, Birkenhead £31,067

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Trade Talk.

Merz & McLellan have removed to Carliol House, Newcastle-on-Tyne.

Tecalemit, Limited, announce that Captain Malcolm Campbell's car and Capt. Bert Hinckler's Avro Avian plane and A D C Cirrus engine were equipped with Tecalemit.

The Openshaw Works of Sir W. G. Armstrong, Whitworth & Company, Limited, were transferred to the new company of Vickers-Armstrongs, Limited, as from January 1, 1928.

Sir W. G. Armstrong, Whitworth & Company, Limited, have secured a contract from the Southern Railway Company for the construction of 14 six-wheeled tenders. The work will be carried out at the Scotswood Works, Newcastle-upon-Tyne.

Watts, Fincham & Company, Limited, 22, Billiter Street, London, E.C.3, announce that although the "Wefco" Works, Southfield Road, Acton, W.4, have been destroyed by fire they are arranging for temporary accommodation during rebuilding, and all orders will be completed promptly. The destruction of the engineering works in no way affects the company's ships, engineers' stores, and shipping business, as these are carried on at the head office in Billiter Street, and at the warehouses at 39/40 Willow Walk, Bermondsey, S.E.1.

The exhaust valves of the Napier engine fitted in Captain Campbell's racing car, "Blue Bird," were made of a special steel, manufactured by Hadfields, Limited, and known as "ERA/ATV" heat-resisting steel. It is interesting to learn that Hadfield's steels were used for the valves of the engine of the British sea-plane that broke all the world's speed records and won the famous Schneider Trophy, also in the engine of the Bentley motor-car which gained the Grand Prix last year.

The London and District Engineering Council, the objects of which are to provide facilities for personal contact between employers and workers, to afford opportunities for general discussion, and to investigate problems affecting industry, was founded at a meeting of the Central Hall, Westminster, on February 27. Mr. V. A. Patterson (Dartford) was elected president. Among those present on the platform were Sir Allan Smith, the chairman of the Management Board of the Engineering and Allied Employers' National Federation, and Mr. J. H. Thomas, M.P.

By a majority of one the Stockport Town Council has decided to accept the tender of Escher Wyss & Company, a Swiss firm, amounting to £35,151, for a 20,000-kw. turbine set for the electricity works. This decision reverses that arrived at at the meeting on February 15, when it was decided to rescind the resolution accepting the Swiss tender passed on February 1. When the matter was before the Council on the first occasion the lowest British tender was £52,000. Since the acceptance of the Swiss tender a British firm has offered to carry out the contract for £42,000.

The aggregate tonnage of vessels launched on the Clyde during January and February constitute a record for the first two months of the year, the total being 117,762 tons, compared with 93,400 tons in 1921, which was the previous record. For January and February last year the aggregate was only 13,350 tons. The February output was 16 ships of 61,751 tons gross, which is also the second highest on record for this month. Orders, too, have been fairly good, for, in addition to the four naval destroyers placed at Clydebank and Greenock, fully half a dozen fairly large-sized ships have been placed.

The Leeds Corporation Electricity Committee has recommended the City Council to accept the tender of the British Thomson-Houston Company, Limited, Rugby, for the two double-cylinder super-efficient 25,000 kw. 3,000 r.p.m. turbo-alternators required for the new power station which is to be erected at Kirstall. The turbo-alternators are rated at 35,714 kva. 10,500/11,500 volts, three-phase, 50-cycles, and the turbines are designed for a working steam pressure of 450 lb. per sq. in. gauge at 750 degrees F. temperature. The total value of the contract, which was secured in the face of very strong Continental competition, is £176,504.

The Yorkshire Copper Works, Limited, of Leeds, continue exceptionally busy on cupro-nickel tubes, particularly in marine circles, where 80/20 and 70/30 alloys of "Yorkshire" cupro-nickel condenser tubes are rapidly becoming standard. The trend of modern condenser practice towards fitting cupro-nickel tubes as a safeguard against corrosion-erosion has increased the demand for this type of tube, and no less than nineteen new ships now in course of construction are being fitted with "Yorkshire" cupro-nickel tubes; these include the electrically-driven liner, to which so much attention has been directed, at present building at Alex. Stephen & Company's yard on the Clyde for the P. & O. Company.

The prospectus of the Broughton Copper Works (1928), Limited, has been issued. The capital is £525,000, divided into 425,000 seven-and-a-half per cent. cumulative preference shares of £1 each, and 2,000,000 ordinary shares of 1s. each. There are no debentures. The public issue consisted of all the preference shares at par and 1,275,000 of the ordinary shares at 2s. each. Applicants were offered the rights of three ordinary to one preference. The new company takes over the business and goodwill of the Broughton Copper Company, Limited, and of John Bibby, Sons & Company (Garston), Limited. The net assets to be taken over are stated to amount to £863,280, excluding goodwill, patents, etc.

The resignation of Sir Hugh Bell from active association with the Dock and Harbour Authorities Association (with which he has been associated since its formation as chairman of the Executive Committee until last year, when he was elected president) was announced at the annual meeting of the Association at Caxton Hall, Westminster. Lord Ritchie, of Dundee, chairman of the Port of London Authority, moving an expression of regret at the resignation of the president, said that the services Sir Hugh Bell had rendered to the docks and harbours of the country extended over a period long before the formation of the Association. He was chairman of the committee which negotiated the war agreement with the Government in regard to the payment of rates and dues, and he also drew up the permanent post-war agreement with the Government on the same matter. His services to them in other directions had also been many and valuable. Sir Hugh Bell said that his association with the authority had throughout been a matter of pride to him.

The sixth annual meeting of the Metropolitan Vickers Long Service Association was held at the Trafford Park Works on February 27. The chair was occupied by Major-General Sir Philip A. M. Nash, who was subsequently elected president of the Association. The proceedings began with a supper served by the canteen staff, and a business meeting followed, when certain alterations in the rules were agreed, and the election of officers took place. A concert followed, most items of which were provided by the M-V. Orchestra and the M-V. Male Voice Choir. The membership of this Association can only be acquired by those who have served the company or its associated concerns for a period of twenty years, and it is worthy of note that one in every 14 of the people at present employed is a member. When the Association began in 1923, it had 302 members at the annual meeting. In 1924 this had increased to 405, in 1925, to 509, in 1926 to 651, in 1927 to 779, and this year to 862. There are now 28 women members, five cases where father and son are members, two cases where husbands and wives are members, and one case where a brother and sister are members. At the end of the past year, Mr. G. E. Bailey, director, qualified for membership. Sir Arthur Whitten Brown, who made the first Atlantic flight with Sir James Alcock, qualified for membership a few days later than Mr. Bailey. At present he is the firm's manager in the Swansea district.

The directors of the United Steel Companies, Limited, have evolved a scheme of arrangement to be submitted at meetings on March 12. The scheme provides that as from January 1, 1928, for a period of three years each class of interest will be paid in cash to the extent that profits are available. The present financial position of the company renders it impossible to permit of the payment of such interest except out of the net earnings during the proposed moratorium period. For the same reason the sinking funds for redemption of the "A" debentures and the "B" and "C" debenture stock will be suspended during this period, the "B" and "C" debenture stockholders being entitled to resort to their respective sinking-fund investments to make good any deficiency of interest. It is further proposed that the £1,016,300 obligations falling due on April 19, 1928, shall be renewed for a period of seven years. Net earnings as from January 1, 1928, will be applied, first, to payment rateably of the interest on (1) "A" debentures, (2) "B" debenture stock, (3) "C" debenture stock, (4) any indebtedness to the company's bankers as at January 1, 1928, in respect of advances to the company or to Steel, Peech & Tozer, or the Appleby Iron Company. Secondly, and subject to the prior payment in full of the interest referred to under "first" above, to the payment rateably of (1) the interest accrued from October 20, 1927, on the obligations, and (2) any sums payable under guarantee of dividend on Strip and Bar preference shares accrued from July 1, 1927. The company's bankers have intimated that if the scheme is adopted by the necessary majorities and is sanctioned by the Court, they will acquiesce in the scheme so far as their interests are concerned.

Contracts Open.

Bromley Cross, Lancs., March 14.—Cast-iron gullies, etc., for year ending March 31, 1929, for the Turton Urban District Council. Mr. V. W. Laithwaite, surveyor, Council Offices, Bromley Cross, near Bolton. Also cable, meters, joint boxes. The Electrical Superintendent, Council Offices, Bromley Cross.

Burnley, March 14.—Ironwork (street grates, etc.), etc., for year ending March 31, 1929. The Borough Engineer and Surveyor, Town Hall, Burnley.

Cymmer, near Port Talbot, March 10.—(1) Steam tubes and fittings; (2) water and gas fittings; (3) cast-iron pipes, during year ending March 31, 1929, for the Glyncorrwg Urban District Council. The Council Offices, Cymmer, near Port Talbot.

Eden, Ireland, March 8.—Providing and laying 1,850 yds. of 4-in. cast-iron water pipe, together with the necessary valves, hydrants, etc., and for the construction of sedimentation tank, two filters and storage tank, etc., for the Larne Rural District Council. Mr. T. Nelson, clerk, Larne.

Great Yarmouth, March 16.—(6) Gully grates, manhole covers and general castings; (7) wrought iron, steel, etc., for 12 months from April 1, 1928, to March 31, 1929, for the Corporation. The Borough Engineer's Office, Great Yarmouth.

Guildford, March 12.—(8) Iron castings for year ending March 31, 1929, for the Town Council. Mr. J. W. Hipwood, borough surveyor, Municipal Offices, Tuns Gate, Guildford.

Haslingden, March 13.—Iron castings during the year ending March 31, 1929, for the Town Council. Mr. R. Austin, sanitary inspector, Health Offices, Haslingden.

Leeds, March 13.—(1) Bolts, nuts and washers; (8) iron and steel; (9) grey iron castings and brake blocks; (13) tubes and fittings; (16) springs; (30) fishbolts, etc., during year ending March 31, 1929, for the Tramways Committee. Mr. W. Chamberlain, general manager and chief engineer, 1, Swinegate, Leeds.

London, S.E.1, March 13-30.—(1) 2,000 buffer plungers; (2) 1,200 helical coil springs; and (5) 70-kw. d.c. steam engine-driven generating set, for the India Store Department, Belvedere Road, Lambeth, S.E.1. (Fee 5s. for each schedule, non-returnable.) Tenders due March 13 for (1) and (2), and March 30 for (5).

North Shields, March 10.—Cast-iron work, iron pipes and fittings, iron and steel, files, bolts and nuts, etc., for half-year ending September 30, 1928, for the Corporation. The Borough Surveyor's Office, 19 and 20, Howard Street, North Shields.

Rishton, March 8.—Gullies, etc., iron castings, etc., for the Urban District Council. Mr. P. Whalley, surveyor, Brook Street, Rishton.

Tyldesley, Lancs., March 16.—Cast-iron gullies, manhole frames and covers, lead piping, stop taps and stop-tap boxes, etc., for 12 months ending March 31, 1929, for the Urban District Council. Mr. F. E. Jones, surveyor, Tyldesley.

Obituary.

The death has occurred in London of Mr. A. E. Stayner, joint managing director of the Hardy Patent Pick Company, Limited, of Heeley, Sheffield. Mr. Stayner, who was 90 years of age and well known to many of the older business men in Sheffield, was of Canadian parentage. In his early thirties he embarked at Halifax, Nova Scotia, for England, and on the voyage became acquainted with Mr. Charles Atwood Hardy, who had invented a miner's pick. A partnership resulted, and subsequently arrangements were made with a Sheffield firm to manufacture the pick. A few years later, in 1872, they decided to form a company, called the Hardy Patent Pick Company, Limited, and they were joined at that time by Mr. Emerson Bainbridge, Mr. A. M. Chambers, and Mr. H. P. Holt. The company's first works were erected in Ecclesall Road, Sheffield, and commenced with six workmen. Mr. Hardy died many years ago, and Mr. Stayner, whose death has now occurred, was joint managing director of the company from its formation. He left Sheffield in 1899 to reside in London and to attend to the London side of the business.

Cadmium as a Rust Protector.—Cadmium has been widely used in galvanising, its electrolytic deposition being simple. Where protection over long periods is needed, it has often replaced zinc, because it gives the same resistance to corrosion with thinner coatings, whilst it is more resistant than nickel, though somewhat inferior to it in mechanical properties.

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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—Business in the Cleveland iron industry continues on a steadily developing basis, and although buying during the past week has been on a somewhat restricted scale as compared with recent more active conditions, the tone of the markets throughout remains confident and firm. As evidence of the improvement already effected in the home market, it may be noted with satisfaction that it no longer pays to import pig-iron from foreign sources, and even in Scotland Cleveland iron is on a competitive basis and is getting a bigger share of the trade, whilst the exports reveal that this quality iron is beginning to penetrate into fresh markets. Thus the prospects for the export trade are bright, and the confidence of home buyers is reflected in recent orders placed up to the end of the second and even the third quarter of the year. Prices as indicated are unchanged, and the following are now uniform quotations both for home deliveries and for export:—No. 1 Cleveland foundry iron, 67s. 6d.; No. 3 Cleveland G.M.B., 65s.; No. 4 foundry, 64s.; No. 4 forge, 63s. 6d.

Shipments of pig-iron from the Tees for February are on a slightly better scale, the total up to February 28 being 17,772 tons, as compared with 15,409 tons to January 28.

A slight improvement can be reported in the East Coast hematite market, although at present business is by no means brisk, but sales are on a rather better scale, and makers are less inclined to continue the cut-throat competition which has depressed prices below the cost of production. It is still possible to shade 70s. per ton for East Coast mixed numbers and 70s. 6d. for No. 1 quality, but these are now the generally recognised market rates. On the North-West Coast prices are still unchanged, Bessemer mixed numbers being quoted at 70s. per ton at works.

LANCASHIRE.—Buying in the local markets for foundry pig during the current week has again been in disappointing volume, many of the Lancashire foundries having at the moment only poorly filled order books, with ample stocks of iron to draw upon. Prices, however, are fairly maintained. Derbyshire makers offer at 72s. 3d. per ton, delivered Manchester or equal distance, Staffordshire at about 71s. 6d., and Cleveland at 78s. 2d. Scottish brands continue to be firmly held at about 86s. to 87s. 6d. per ton, delivered Manchester.

THE MIDLANDS.—Pig-iron consumers in South Staffordshire and adjacent districts continue buying on an extremely cautious scale, business being mostly confined to current needs. The following figures about represent average current quotations:—Northamptonshire No. 3, 64s. to 65s.; Derbyshire No. 3, 64s. to 65s.; North Staffordshire, 64s. to 65s., all at furnace; Lincolnshire, 72s. 6d. delivered; and Scotch No. 3, 88s. 6d., also delivered.

SCOTLAND.—Conditions in the foundry industry of the North do not at the moment favour increased consumption of Scotch pig-iron, both light and pipe castings being rather slow in demand. So far, however, the price of No. 3 foundry iron is unaffected, the quotation ruling as previously at 70s. per ton at furnaces.

Finished Iron.

Manufacturers of most descriptions of finished material still complain of the difficulty in getting orders for crown and the cheaper grades of iron, and there is considerable competition for the limited tonnage now being placed. In South Staffordshire prices continue to vary considerably, and anything from £9 5s. to £10 5s. is being quoted for crown iron. Nut and bolt iron from the local mills is quoted just under £9. The advanced price for Continental No. 3 iron is maintained, and the present quotations delivered to works in the Darlaston area is £6 7s. 6d. to £6 10s. Marked bars, which are in fair demand, are unchanged at £12 10s. at makers' works. In Lancashire the demand for the local products is still on the usual quiet scale. There has been no change in the price situation, however, and makers continue to express the view that any further reduction is extremely unlikely. Lancashire crown bars are currently quoted at £10 per ton, and seconds at £9 10s. Merchant parcels of the former are being offered on the basis of 14s. per cwt., less 2½ per cent. and including delivery to consumers' works.

Steel.

The announcement of the placing of extensive contracts on the Clyde for the building of four destroyers has helped to brighten to some extent the outlook of the Scottish steel industry. The steelmakers in consequence are getting steady specifications from the home trade, but, although there is a fair amount of shipbuilding material needed, in many cases it is reserved for certain works, as many of the shipyards have connections with steelworks. In semi-products Continental quotations are very firm. Foreign 2-in. square soft Thomas are named at £5 15s.; 2½ in. and up, £5 13s. 6d.; sheet bars, £5 15s. 6d.; and blooms, £5 10s. per ton, delivered works in the South Staffordshire district. Prices for billets from the English works vary from £6 to £6 5s., and at the lower figure Welsh supplies are also available. The home works are receiving more support evidently, but not sufficient to warrant any alteration in the price. The tinplate market is still a little quiet, but there is a slight increase in the volume of business done. The works are busy, and are gradually extending their order books.

Scrap.

Markets for all descriptions of scrap metal for foundry purposes continue to vary greatly, both in extent of demand and current quotations, as, for example, on Tees-side, where merchants affirm that, in spite of the heavy transport charges, they can dispose of heavy steel scrap in Scotland more profitably than to the local works. In that area there is a small, but steady, trade in heavy cast iron, with ordinary quality at 62s., whilst machinery quality in handy pieces realises 66s. per ton. Buyers of cast-iron borings have no difficulty in covering their needs at 43s. per ton. In the Scottish market machinery cast-iron scrap is unchanged at 70s., in pieces not exceeding 1 cwt.; and for heavy ordinary cast iron to the same specification 5s. per ton less. Steelworks cast-iron scrap in furnace sizes is at 63s. 6d. to 65s. per ton. Old cast-iron railway chairs are still around 67s. 6d. to 70s. per ton. The above prices are all per ton delivered consumers' works.

Metals.

Copper.—Values of warrant copper during the past week were subject to a slight downward variation, though quotations for fine-grade metal were only affected to a fractional extent. The position at the moment may be summarised as follows:—Stocks in this country are comparatively small, which is regarded as a warning against a renewal of aggressive forward selling, although the fact that the old bear account has been already fairly well levelled up lately tended to eliminate a source of support which has resulted in the contraction of the premium on cash warrants to about 5s. a ton.

Official closing prices of standard copper have been as follow:—

Cash: Thursday, £60 1s. 3d. to £60 2s. 6d.; Friday, £60 2s. 6d. to £60 3s. 9d.; Monday, £60 12s. 6d. to £60 13s. 9d.; Tuesday, £61 to £61 1s. 3d.; Wednesday, £60 17s. 6d. to £60 18s. 9d.

Three Months: Thursday, £59 18s. 9d. to £60; Friday, £59 18s. 9d. to £60; Monday, £60 10s. to £60 11s. 3d.; Tuesday, £60 17s. 6d. to £60 18s. 9d.; Wednesday, £60 13s. 9d. to £60 15s.

Tin.—In the absence of further sensational developments, the position in the market for standard cash tin has steadied to some extent, and closing prices even marked a small advance last week. The future of tin, although viewed in a somewhat more hopeful light, is still anything but clear, yet there is little doubt that the worst of the adverse features which dominated the situation for a considerable time past has been seen. A further addition has been made to the home stocks, and more tin is understood to have gone into warehouse lately, but imported tin, such as Straits and Dutch, is more firmly held.

Official closing prices of standard tin have been as under:—

Cash: Thursday, £228 15s. to £229; Friday, £229 10s. to £229 12s. 6d.; Monday, £232 5s. to £232 7s. 6d.; Tuesday, £231 17s. 6d. to £232 2s. 6d.; Wednesday, £230 5s. to £230 10s.

Three Months: Thursday, £231 7s. 6d. to £231 10s.; Friday, £231 15s. to £232; Monday, £234 12s. 6d. to £234 15s.; Tuesday, £234 2s. 6d. to £234 5s.; Wednesday, £232 15s. to £232 17s. 6d.

Spelter.—An explanation of the recent depression in the market for ordinary spelter is provided in the comments of R. Wolff & Company, who write:—Prices have sagged owing to Continental liquidations and bear selling. Consumers have again been in the market, but not on such a large scale as previously. The ore situation in America and the increased stocks of metal are weighing on the market here, and unless producers take steps to curtail production values may possibly continue to decline, although we do not anticipate much lower prices.

The following are the week's prices:—

Ordinary: Thursday, £24 18s. 9d.; Friday, £24 17s. 6d.; Monday, £25 1s. 3d.; Tuesday, £25 3s. 9d.; Wednesday, £25 2s. 6d.

Lead.—The market for soft foreign pig continues weak and depressed conditions, due to liquidation by disheartened holders and slack buying by consumers under the influence of the German troubles. Later a fair rally ensued on some purchases attracted by needy users short of stock, and the market closes round 5s. above the worst, which marked the lowest point touched since the year 1922 at £19 10s.

The week's prices are appended:—

Soft foreign (prompt): Thursday, £19 18s. 9d.; Friday, £19 10s.; Monday, £19 15s.; Tuesday, £20 5s.; Wednesday, £19 18s. 9d.

Reports and Dividends.

Bruce Peebles & Company, Limited.—Ordinary dividend, 10 per cent. per annum.

Rivet, Bolt and Nut Company, Limited.—Dividend, 10 per cent., free of tax, for 1927.

W. Canning & Company, Limited.—Dividend 10 per cent. per annum, and bonus 6d. per share, both less tax, in respect of 1927.

Electrical Distribution of Yorkshire, Limited.—Net profit, £63,217; dividend, 9 per cent. for year; reserve, £13,000; brought forward, £15,836; carry forward, £18,723.

General Hydraulic Power Company, Limited.—Depreciation, etc., £32,000; net revenue, £59,485; dividend for year on ordinary stock, 6½ per cent.; carry forward, £7,806.

Mather & Platt, Limited.—Net profits, £232,946; transferred to income-tax account, £40,910; brought forward, £164,458; ordinary dividend, 15 per cent., free of tax; carried forward, £131,945.

Thomas Robinson & Son, Limited.—Profit for year, £29,051; brought forward, £28,436; total, £57,487; dividend on ordinary shares, 1s. 6d. per share, making 10 per cent. for year; carry forward, £28,310.

Fisher & Ludlow (1920), Limited.—Net profit, £37,919; brought in, £10,050; dividend, 12½ per cent. (actual), less tax, on ordinary shares, making 20 per cent.; reserve, £12,500; staff fund, £500; forward, £11,969.

Crompton Parkinson, Limited.—Interim dividend, 8 per cent. per annum on cumulative preference shares for 9 months ended December 31, 1927; interim dividend 2s. 6d. per share on deferred ordinary shares for period ended December 31.

Southall Bros. & Barclay, Limited.—Cash bonus to employees, £3,700; pension fund, £2,000; profit, £53,540; brought in, £36,562; dividend on ordinary shares, 10 per cent. per annum, free of tax, plus bonus 1s. 6d. per share, also free of tax; reserve, £45,000; forward, £15,852.

Delta Metal Company, Limited.—Net profit, £55,258; brought in, £14,640; dividend 12½ per cent., with bonus 6d. per share (free of tax); reserve against premises, plant and installation account, £15,000; carry forward, £16,109. Directors propose to issue 42,000 ordinary shares, £1, at £2 10s. per share. Shares offered to shareholders in proportion of one share for every six now held.

Since the passing of the Electricity Supply Act it is interesting to note the rapid strides which have been made in the electrification of rural areas. A recent contract in connection with this development is one received by W. T. Henley's Telegraph Works Company, Limited, for a high-tension feeder in the form of underground cables and overhead lines to supply the towns of Saxmundham, Wickham Market, Melton, Orford and Hollesley from the Ipswich mains. The contract also covers the installation of the underground and overhead low-tension distribution cables in these five towns which will now very soon be linked up electrically with Ipswich, as well as the house-service cables and substation switchgear.

XUM

Sterling

MOULDING BOXES

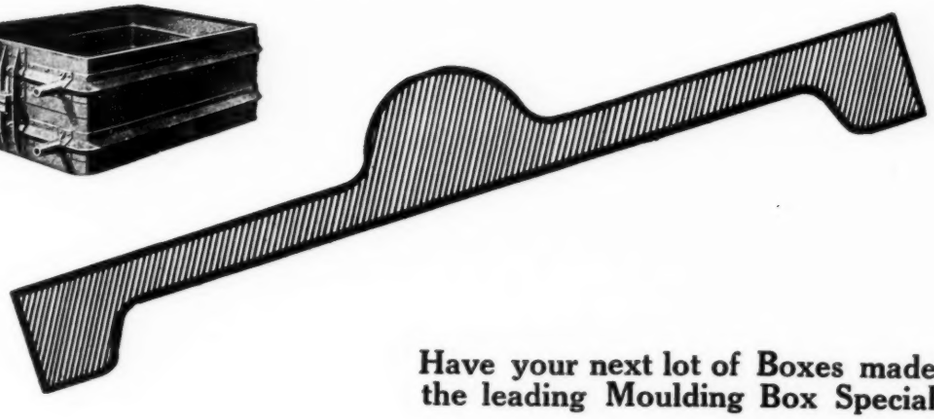
¶ LIGHTNESS AND EASE OF HANDLING;
¶ ROBUST CONSTRUCTION;
¶ DURABILITY AND LONG LIFE;
¶ PERMANENT ACCURACY.

These are the paramount essentials of the modern moulding box.

Sterling Boxes embody all these qualities. They are made from solid ribbed rolled steel of the special section shown below.

Some of the largest and most up-to-date foundries in the country are now completely equipped with Sterling Boxes.

All Sterling Boxes are made to suit the individual requirements of each Foundry. We will drill them to match up to your existing pattern plates or odd-sides and fit them with bars to suit your special patterns.



Have your next lot of Boxes made by the leading Moulding Box Specialists.

STERLING FOUNDRY SPECIALTIES LTD., BEDFORD

London Office:
13, VICTORIA STREET, S.W.1.

Telephone: 3345 BEDFORD.
Telegrams: "STERFLASK, BEDFORD."
Code: WESTERN UNION.

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	60 17 6
Three months	60 13 9
Electrolytic	66 10 0
Tough	63 15 0
Best selected	64 5 0
Sheets	92 0 0
India	76 0 0
Wire bars	66 15 0
Do. March	66 10 0
Do. April	66 10 0
Ingot bars	66 10 0
H.C. Wire rods	71 5 0
Off. av. cash, Jan.	61 18 11 1/32
Do. 3 mths., Jan.	61 15 0 1/16
Do., Sttlmnt., Jan.	61 18 10 3/4
Do., Electro, Jan.	66 16 1 7/8
Do., B.S., Jan.	66 4 8 5/8
Aver. spot price, copper, Jan.	61 18 11
Do., Wire bars, Jan.	67 1 1 1/4
Solid drawn tubes	13d.
Brazed tubes	13d.
Wire	9 1/2d.

BRASS.

Solid drawn tubes	11 1/2d.
Brazed tubes	13 1/2d.
Rods, drawn	10 1/2d.
Rods, extd. or rlld.	7 1/2d.
Sheets to 10 w.g.	10 1/2d.
Wire	9 1/2d.
Rolled metal	9 1/2d.
Yellow metal rods	7 1/2d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8 1/2d.

TIN.

Standard cash	230 5 0
Three months	232 15 0
English	235 5 0
Bars	239 0 0
Straits	236 0 0
Australian	235 0 0
Eastern	237 10 0
Banca	237 0 0
Off. av. cash, Jan.	253 6 5 1/32
Do., 3 mths., Jan.	252 5 1 1/16
Do., Sttlmt., Jan.	253 6 4 1/16
Aver. spot, Jan.	253 6 5

SPELTER.

Ordinary	25 2 6
Remelted	25 0 0
Hard	19 10 0
Electro 99.9	29 7 6
English	25 10 0
India	21 5 0
Zinc dust	33 0 0
Zinc ashes	8 0 0
Off. aver., Jan.	26 1 9 3/32
Aver., spot, Jan.	26 2 6

LEAD.

Soft foreign ppt.	19 18 9
English	21 5 0
Off. average, Jan.	21 19 10 13/32
Average spot, Jan.	21 15 5 1/2

ZINC SHEETS, &c.

Zinc sheets, English	35 0 0
Do. V.M. ex whf.	32 5 0
Rods	40 0 0
Boiler plates	30 0 0
Battery plates	31 10 0

ANTIMONY.

Special brands, Eng.	64 10 0
Chinese	44 0 0
Crude	36 0 0

QUICKSILVER.

Quicksilver	20 10 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	8 15 0
45/50%	12 17 6
75%	20 10 0
Ferro-vanadium—	
35/40%	14/3 lb. va.
Ferro-molybdenum—	
70/75% c. free	4/10 lb.
Ferro-titanium—	
23/25% carbonless	11d.
Ferro-phosphorus, 20/25%	£17 15 0
Ferro-tungsten—	
80/85%, c. fr.	1/3 lb.
Tungsten metal powder—	
98/99%	1/7 1/2 lb.
Ferro-chrome—	
2/4% car.	£32 15 0
4/6% car.	£22 5 0
6/8% car.	£22 7 6
8/10% car.	£22 5 0
Ferro-chrome—	
Max. 2% car.	£35 0 0
Max. 1% car	£41 0 0
Max. 0.70% car	£50 0 0
70%, carbonless	1/2 lb
Nickel—99%, cubes or pellets	£175 0 0
Ferro-cobalt	9/6 lb.
Aluminium 98/99%	£105 0 0
Metallic chromium—	
96/98%	2/10 lb.
Ferro-manganese (net)—	
76/80%, loose	£13 10 0
76/80%, packed	£14 10 0
76/80%, export	£13 5 0
Metallic manganese—	
94/96%, carbonless	1/10 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 6
Finished bars, 18% tungsten	£0 3 0

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/2 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 1/16 in.	1/- lb.
Flats, 1/2 in. × 1/4 in. to under 1 in. × 3/8 in.	3d. lb.
Do., under 1/4 in. × 1/4 in.	1/-lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£ s. d.
South Wales—	
Hvy. steel	3 1 0 to 3 2 6
Bundled steel and shrngs.	2 15 0 to 3 0 0
Mixed iron and steel	2 15 0 to 2 16 6
Heavy cast iron	2 18 0 to 3 0 0
Good machinery for foundries	3 2 6 to 3 5 0
Cleveland—	
Heavy steel	2 15 0
Steel turnings	2 8 6
Cast iron borings	2 3 0
Heavy forge	3 10 0
Bushelled scrap	3 2 6
Cast-iron scrap	3 2 0 to 3 6 0
Lancashire—	
Cast-iron scrap	3 5 0
Hvy. wrought	3 2 6
Steel turnings	2 2 6
London—Merchants' buying prices delivered yard.	
Copper (clean)	52 0 0
Brass (clean)	38 0 0
Lead (less usual draft)	17 10 0
Tea lead	15 10 0
Zinc	16 0 0
New aluminium cuttings	75 0 0
Braziery copper	47 0 0
Gunmetal	48 0 0
Hollow pewter	165 0 0
Shaped black pewter	125 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

	£ s. d. to £ s. d.
N.E. Coast—	
Foundry No. 1	67/6
Foundry No. 3	65/-
Foundry No. 4	64/-
Forge No. 4	63/6
Hematite No. 1	70/-
Hematite M/Nos.	69/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	83/-
,, d/d Birm.	87/6
Midlands—	
Staffs. common*	—
,, No. 4 forge	62/6
,, No. 3 fdry.	64/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	—
,, fdry. No. 3	60/-
Derbyshire forge	60/-
,, fdry. No. 3	64/-
,, basic	—
Scotland—	
Foundry No. 1	—
,, No. 3	70/-
Hem. M/Nos.	73/6
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	67/6
Lincs. forge	64/-
,, fdry. No. 3	67/-
E.C. hematite	82/6
W.C. hematite	85/6
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	72/3
Northants foundry No. 3	—
Dalzell, No. 3	100/- to 102/6
Summerlee, No. 3	87/6 to 94/-
Glengarnock, No. 3	87/6 to 94/-
Gartsherrie, No. 3	87/6 to 94/-
Monkland, No. 3	87/6 to 94/-
Coltness, No. 3	87/6 to 94/-
Shotts, No. 3	87/6 to 94/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£ s. d. to £ s. d.
Iron—	
Bars (cr.) nom.	9 5 0 to 10 10 0
Angles	—
Tees to 3 united ins.	—
Nut and bolt iron	9 0 0
Hoops	12 0 0
Marked bars (Staffs.) f.o.t.	12 10 0
Gas strip	12 0 0
Bolts and nuts, 3/4 in. × 4 in.	15 5 0
Steel—	
Ship plates	8 7 6 to 8 12 6
Boiler plts.	10 10 0
Chequer plts.	10 5 0
Angles	7 17 6
Tees	8 17 6
Joists	7 17 6
Rounds and squares, 3 in. to 5 1/2 in.	7 10 0
Rounds under 3 in. to 3/8 in. (Untested)	7 15 0 and upwards
Flats, over 5i n. wide and up	8 17 6
Flats, 5 in. to 1 1/2 in.	7 17 6
Rails, heavy	8 2 6 to 8 7 6
Fishplates	12 10 0
Hoops (Staffs.)	10 10 0
Black sheets, 24g.	10 2 6
Galv. cor. shts., 24g.	13 7 6
Galv. fencing wire 8g. plain	12 10 0
Billets, soft	£6 0 0 to 6 10 0
Billets, hard	7 12 6
Sheet bars	£5 12 6 to 5 15 0
Tin bars	£5 12 6 to 5 15 0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 2 1/2
Sheet to 10 w.g.	1 3
Wire	1 3 3/4
Rods	1 3
Tubes	1 8 1/2
Castings	1 2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3 1/2 to 1/9 1/2
To 15 in. wide	1/3 1/2 to 1/9 1/2
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4 1/2 to 1/10 1/2
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5 1/2
Ingots rolled to spoon size	1/- to 1/8 1/2
Wire round—	
3/0 to 10 G.	1/6 1/2 to 2/1 1/2

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	20.76
No. 2 foundry, Valley	17.25
No. 2 foundry, Birm.	16.00
Basic	18.76
Bessemer	19.26
Malleable	19.01
Grey forge	18.51
Ferro-mang. 80% d/d	100.00
Bess rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	34.00
Wire rods	44.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.85
Tank plates	1.85
Beams, etc.	1.85
Skelp, grooved steel	1.85
Skelp, sheared steel	1.85
Steel hoops	2.20
Sheets, black, No. 24	2.90
Sheets, galv., No. 24	3.65
Sheets, blue an'l'd., 9 and 10	2.10
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.35
Tinplate, 100 lb. box	$5.25

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	—
,, furnace	14/1 1/2
Other Districts, foundry	—
,, ,, furnace (basis)	12/- to 13/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14	box	17/9
,,	28×20	,,	35/6
,,	20×10	,,	—
,,	18 3/4×14	,,	—
C.W.	20×14	,,	16/10 1/2
,,	28×20	,,	—
,,	20×10	,,	—
,,	18 3/4×14	,,	—
Terneplates	28×20	—	per box basis f.o.b.

SWEDISH IRON.

Bars, hammered,	£17 10 0 to £18 10 0
Rolled Ord.	£15 0 0 to £15 10 0
Nail rods	£15 7 6 to £15 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£8 to £12
Pig-iron	£5 15 0 to

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½% ..	.. 45%
Water	63⅓% ..	.. 40%
Steam	60% ..	.. 35%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£ s. d.	
Mar. 1 ..	60 1 3	dec.	10/-
,, 2 ..	60 2 6	inc.	1/3
,, 5 ..	60 12 6	,,	10/-
,, 6 ..	61 0 0	,,	7/6
,, 7 ..	60 17 6	dec.	2/6

Electrolytic Copper.

	£ s. d.	
Mar. 1 ..	66 0 0	No change
,, 2 ..	66 0 0	,, ,,
,, 5 ..	66 5 0	inc. 5/-
,, 6 ..	66 10 0	,, ,,
,, 7 ..	66 10 0	No change

Standard Tin (cash).

	£ s. d.		
Mar. 1 ..	228 15 0	dec.	5/-
,, 2 ..	229 10 0	inc.	5/-
,, 5 ..	232 5 0	,,	55/-
,, 6 ..	231 17 6	dec.	7/6
,, 7 ..	230 5 0	,,	32/6

Tin (English ingots).

	£ s. d.		
Mar. 1 ..	233 15 0	dec.	15/-
,, 2 ..	234 10 0	inc.	15/-
,, 5 ..	237 5 0	,,	55/-
,, 6 ..	237 0 0	dec.	5/-
,, 7 ..	235 5 0	,,	35/-

Zinc Sheets (English).

	£ s. d.	
Mar. 1 ..	35 0 0	No change
,, 2 ..	35 0 0	,, ,,
,, 5 ..	35 0 0	,, ,,
,, 6 ..	35 0 0	,, ,,
,, 7 ..	35 0 0	,, ,,

Spelter (ordinary).

	£ s. d.		
Mar. 1 ..	24 18 9	dec.	3/9
,, 2 ..	24 17 6	,,	1/3
,, 5 ..	25 1 3	inc.	3/9
,, 6 ..	25 3 9	,,	2/6
,, 7 ..	25 2 6	dec.	1/3

Lead (English).

	£ s. d.		
Mar. 1 ..	20 15 0	dec.	5/-
,, 2 ..	20 15 0	No change	
,, 5 ..	21 0 0	inc.	5/-
,, 6 ..	21 10 0	,,	10/-
,, 7 ..	21 5 0	dec.	5/-

AVERAGE MONTHLY PRICES OF RUBIO ORE (MIDDLESBROUGH).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1890	0 15 4	0 15 4	0 15 4	0 15 4	0 15 4	0 15 4	0 15 4	0 14 3	0 14 3	0 15 7½	0 15 7½	0 15 7½	0 15 2¾
1891	0 15 7½	0 14 2½	0 14 2½	0 14 2½	0 13 6½	0 13 6	0 13 3¾	0 13 0	0 12 11	0 13 0	0 13 7	0 13 1	0 14 9½
1892	0 13 1	0 12 9	0 12 9	0 12 9	0 12 9	0 11 10½	0 12 1	0 12 1	0 12 2	0 12 0	0 12 0	0 11 11	0 12 4¼
1893	0 11 11	0 11 5½	0 11 10	0 11 10	0 12 1½	0 12 3	0 12 1½	0 12 3	0 12 1	0 12 4	0 12 4½	0 12 6	0 12 0½
1894	0 12 6	0 12 6	0 12 7½	0 12 1½	0 12 4	0 12 1	0 12 0	0 12 0½	0 11 10½	0 12 2	0 12 0	0 12 0	0 12 1¼
1895	0 12 0	0 12 0	0 11 10	0 12 0	0 12 0	0 12 3	0 12 3	0 12 4	0 12 4	0 12 6	0 12 7	0 12 6	0 12 2½
1896	0 12 6	0 12 6	0 12 9	0 12 9	0 12 9	0 12 7	0 12 9	0 12 9	0 12 9	0 13 6	0 15 0	0 14 9	0 13 1
1897	0 15 3	0 15 6	0 15 3	0 15 0	0 14 0	0 14 3	0 14 3	0 14 0	0 14 0	0 15 0	0 14 3	0 15 3	0 14 8
1898	0 15 0	0 14 4	0 14 9	0 14 6	0 15 0	0 15 0	0 14 0	0 14 0	0 14 0	0 14 9	0 15 0	0 14 9	0 14 7
1899	0 15 0	0 15 3	0 15 6	0 15 6	0 15 9	0 16 0	0 17 6	0 18 0	0 17 9	0 18 0	0 19 0	1 0 0	0 16 11½
1900	1 1 0	1 0 6	1 1 0	1 0 9	1 1 0	1 1 0	1 1 3	1 1 6	1 1 3	1 1 3	1 0 0	0 18 0	1 0 8½
1901	0 17 6	0 16 0	0 15 0	0 14 6	0 15 6	0 15 9	0 14 9	0 15 3	0 15 9	0 15 9	0 15 9	0 15 9	0 15 7½
1902	0 15 6	0 15 0	0 16 0	0 16 0	0 15 6	0 15 3	0 15 6	0 16 0	0 16 0	0 16 0	0 15 9	0 15 6	0 15 8½
1903	0 15 6	0 16 0	0 16 6	0 16 3	0 16 3	0 16 10	0 15 9	0 15 6	0 15 6	0 14 9	0 14 9	0 15 1	0 15 8
1904	0 14 9	0 15 3	0 15 1	0 15 4	0 15 3	0 15 0	0 14 5	0 14 6	0 14 6	0 14 6	0 14 6	0 14 7	0 14 9½
1905	0 15 3	0 15 6	0 15 0	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 16 6	0 18 6	0 18 9	0 18 9	0 16 2½
1906	1 0 0	1 1 6	1 0 0	1 0 0	0 19 6	1 0 0	0 19 6	0 19 4	1 0 6	1 1 6	1 1 9	1 3 6	1 0 7
1907	1 3 6	1 2 6	1 2 6	1 2 0	1 1 6	1 2 3	1 2 3	1 2 0	1 1 0	0 19 0	0 18 9	0 17 6	1 1 2½
1908	0 16 6	0 15 0	0 15 6	0 15 6	0 15 3	0 15 0	0 15 0	0 14 9	0 15 0	0 16 0	0 16 0	0 16 0	0 15 6½
1909	0 15 9	0 16 3	0 16 0	0 16 0	0 16 3	0 16 6	0 16 0	0 16 0	0 17 0	0 17 0	0 17 6	0 17 6	0 16 6
1910	1 0 4	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 3	1 0 3	1 0 6½	1 1 3	1 1 5	1 0 9½
1911	1 2 2½	1 2 6	1 2 6	1 1 11½	1 0 11½	0 19 6	0 19 0	0 19 0	0 19 1½	0 19 6	1 0 0½	1 1 6½	1 0 7½
1912	1 2 3	1 2 6	1 2 6	1 1 1½	1 1 6	1 1 6	1 1 6	1 2 3	1 2 6	1 3 0	1 3 0	1 2 11	1 2 2½
1913	1 2 9	1 2 2	1 1 7½	1 1 6	1 0 8½	1 0 0	1 0 0	1 0 0	0 19 10½	0 19 1½	0 19 0	0 19 0	1 0 5½
1914	0 18 7½	0 18 0	0 18 0	0 17 9	0 17 6	0 17 6	0 17 1½	0 19 7½	0 18 11½	0 17 10½	0 18 7½	1 1 0½	0 18 5½
1915	1 7 7½	1 8 6	1 9 3	1 10 2½	1 8 6	1 6 4	1 5 10½	1 6 0	1 6 10½	1 10 8½	1 13 0	1 17 10	1 9 1½
1916	1 18 6	2 0 1½	2 2 6½	2 0 6½	1 15 0	1 16 3	1 18 0	1 18 0	1 18 0	—	—	—	—
1917	} Price Fixed												
1918													
1919	—	—	—	—	2 5 7½	2 14 4½	2 16 4½	2 14 0	2 13 4½	2 13 0	2 12 7½	2 11 9	—
1920	2 17 0	3 7 9	2 15 6	3 6 7	3 0 0	2 15 0	2 14 0	2 9 9	2 7 6	2 11 0	2 12 3	2 10 0	2 15 0
1921	2 1 0	2 0 1½	1 18 3	1 17 6	1 17 6	1 17 6	1 17 6	1 5 0	1 8 9½	1 7 9	1 7 0	1 7 0	1 13 8½
1922	1 6 7½	1 5 10½	1 6 11	1 7 0	1 7 0	1 7 0	1 5 3	1 4 9½	1 4 2½	1 3 3½	1 2 6	1 2 3	1 5 2½
1923	1 2 9½	1 4 6½	1 5 2	1 4 8½	1 4 6	1 4 0	1 3 6	1 3 0	1 3 0	1 3 0	1 3 2½	1 4 9	1 3 10½
1924	1 4 2½	1 4 6	1 4 0	1 3 7½	1 3 8½	1 3 6	1 2 11	1 2 6	1 2 1½	1 1 7½	1 2 3	1 2 6	1 3 1
1925	1 2 6	1 2 1½	1 2 0	1 2 0	1 1 6	1 0 6	1 0 0	1 0 0	1 0 0	1 0 3	1 0 10½	1 1 1½	
1926	1 1 1½	1 1 6	1 1 6	1 1 3½	1 1 3	1 1 5½	1 1 6	1 1 6*	1 1 0*	1 1 6*	1 1 6*	*	1 1 4½
1927	1 2 1½	1 2 3	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 7½	1 1 0	1 1 0	1 1 0	1 1 0	1 1 0	1 1 7½
1928	1 1 0	1 1 1½	—	—	—	—	—	—	—	—	—	—	—

* Prices nominal.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

PIG IRON

REGISTERED TRADE MARK

LUMPS

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

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